Response to a Ricin Incident:
Guidelines for Federal, State, and Local Public Health and Medical Officials

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1.0 Purpose and Scope

1.1 Purpose

Many "white powder" incidents occur each day at Federal and other buildings across the United States. In February 2004, white powder found in the Dirksen Senate Office Building in Washington, D.C. tested positive for ricin. The Office of Public Health Emergency Preparedness (OPHEP) within the Department of Health and Human Services (HHS) commissioned an After-Action Report (AAR) of the Dirksen incident, focusing on the public health and medical aspects of the response.[1] One of the key findings of the AAR was the need for a ricin-specific response protocol.

The purpose of this document is to provide a template for a public health and medical response to a ricin incident and some of the recovery aspects that such an incident might warrant. It includes current information on ricin with respect to field sampling and laboratory testing, epidemiology and public health surveillance, medical treatment, risk communication, and environmental assessment, cleanup, and remediation. The document attempts to establish a comprehensive approach for domestic incident management involving ricin, again concentrating on public health and medical aspects.

Ricin is a toxin derived from the castor bean plant. Ricin can be extracted relatively easily from castor beans; most of these preparations can be found in open-source literature (see Chapter 4 for more details). Exposure to ricin can occur through several routes including inhalation, ingestion, skin and eye exposure, and injection. The most lethal route of exposure is through injection, but that would necessarily be a limited event that would not require a coordinated public health response. Exposure to ricin by inhalation would pose the most serious public health and medical scenario. Exposure to ricin in high doses can cause organ failure and death with initial symptoms developing within 4-8 hours of inhalational exposure and up to 10 hours for ingestional exposure.[2] Ricin is a non-contagious agent, and there is currently no approved treatment or cure for ricin exposure in humans. However, the symptoms can be managed with medical intervention if recognized early, and if the dose is not lethal.

1.2 Audience and Scope

This document was developed as a technical resource for the public health and medical response to an actual or suspected ricin incident and is designed for a wide audience. The audience includes first responders discovering or responding to a potential aerosolizable ricin threat, medical practitioners involved with victims/patients displaying signs of potential ricin intoxication, laboratory scientists involved in testing a suspicious sample that may be ricin, public health and law enforcement officials tasked with carrying out epidemiological and criminal investigations in a ricin incident, and senior policymakers who will need to implement decisions regarding manning, funding, and planning response efforts.

This document also explores the coordination and interaction that must occur in a bioterrorism situation with local, State, or Federal (Federal Bureau of Investigation) law enforcement; the Department of Homeland Security (if applicable); and also with agencies responsible for cleanup and remediation (Environmental Protection Agency) and any other appropriate agencies involved in the short- and long-term response.

1.3 Document Use

This document provides technical information on activities including initial actions when a potential threat is discovered, worker health and safety issues (e.g., selection of personal protective equipment), laboratory sampling and analysis for putative ricin samples, applicable medical countermeasures for ricin intoxication, public health concerns and risk communication strategies, and a discussion of decontamination issues and technologies. As such, this document should be used as reference material; all sections may not apply to all audiences.

1.4 Document Development

This document was developed by OPHEP in conjunction with the CNA Corporation, a not-for-profit organization providing research, analysis, and technical services to the government and other organizations. The initial draft of this document was used as a "straw man" for a workshop that was held January 10, 2006, at HHS Headquarters in Washington, D.C. Subject matter experts (SMEs) attending the workshop and other outside SMEs reviewed, commented on, and provided input to this document. The next version of the document incorporated the SME input. Optimally, this document will be updated on a regular basis as new information regarding the response to a ricin incident becomes available.

References

[1]McCue B, et al., Dirksen Building White Powder Incident After-Action Report on Medical and Public Health, CNA Corporation, Alexandria VA, IPR11089, August 2005.
[2]NIOSH Emergency Response Card: Ricin. February 18, 2004. Available at: <http://www.bt.cdc.gov/agent/ricin/erc9009-86-3.asp>

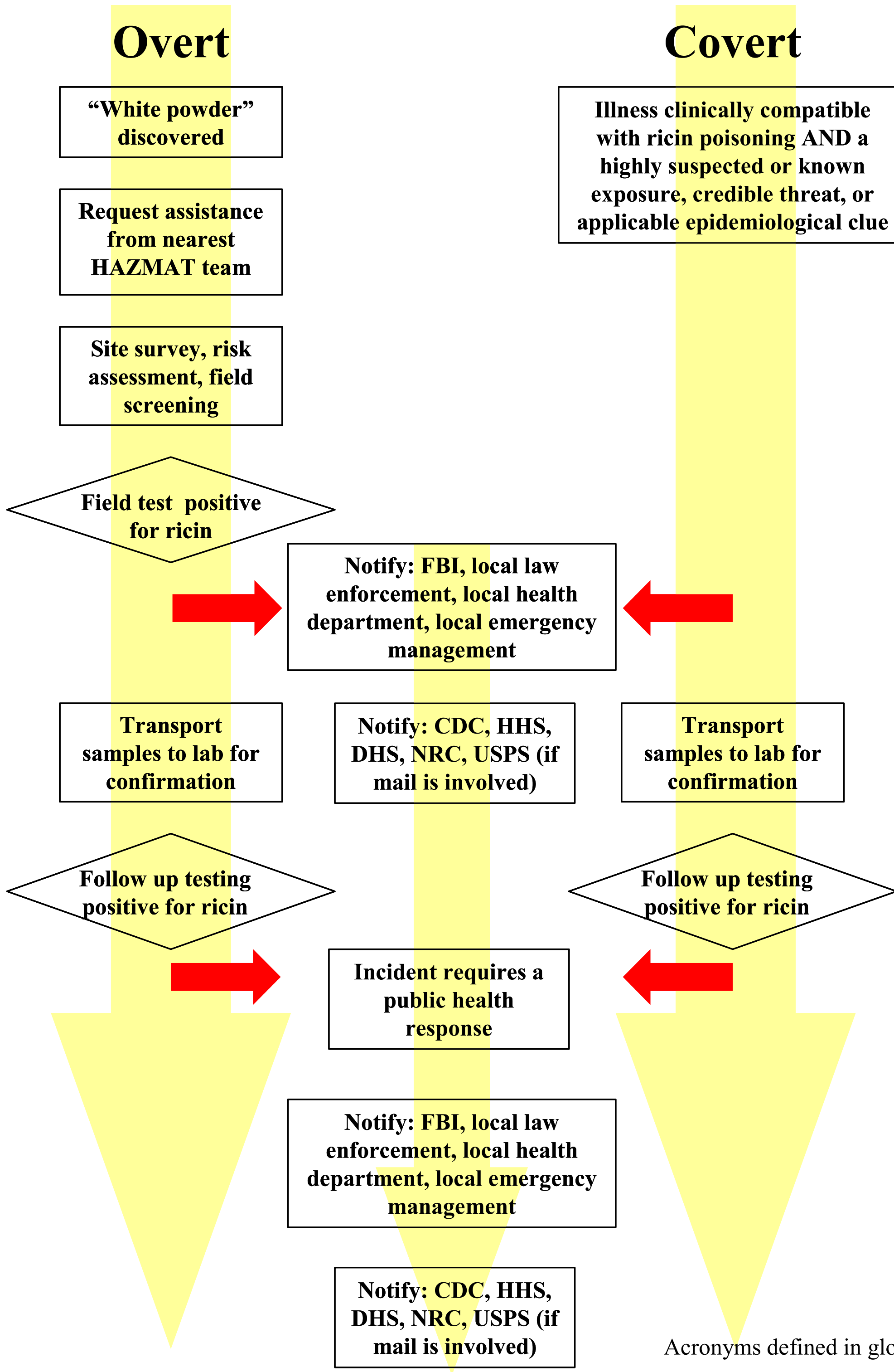
2.0 Overview and Response

This chapter provides an overview of the response to a ricin incident from discovery to confirmation of ricin. The event could be either overt (e.g., discovery of a "white powder") or covert (e.g., discovery of symptoms consistent with ricin poisoning). In any event, the following key steps apply and are discussed in this section:

- Conduct a preliminary assessment to determine if there is a credible threat (overt event).
- If a credible threat is likely (e.g., positive field test result for ricin), notification should be made to the FBI and local law enforcement, public health, and emergency management agencies.
- State and local agencies have the primary responsibility for response and are supported by Federal agencies as outlined in the National Response Plan (NRP).
- Coordination of the response from the local to the Federal level will occur in accordance with the NRP.

Presented on the following page is a flow diagram depicting the initial response and notification process during an overt or covert ricin incident (acronyms are defined in the glossary at the end of this document).

Initial response and notification process



Acronyms defined in glossary

2.1 Discovery

Discovery of ricin contamination may occur in several ways depending on whether the event is overt or covert. In an overt event, discovery will most likely occur through physical evidence of a suspicious substance possibly coupled with a threat, as in the 2003 "Fallen Angel" case where a vial containing ricin was discovered in a South Carolina mail facility.[1] In a covert event, discovery will most likely occur through epidemiological or medical observation of affected persons. Ricin intoxication can be manifested through various symptoms, depending on the route of administration. Signs and symptoms of inhalational ricin poisoning can develop within 4-8 hours of exposure (there may be a greater range of time to noticeable symptoms in some cases) and may include the following:[2]

- Sudden onset of congestion of nose and throat
- Respiratory distress possibly leading to respiratory failure
- Difficulty breathing
- Flu-like symptoms of fever, nausea, muscle pain.

Mild symptoms of intestinal ricin poisoning such as nausea, vomiting, and cramping will usually develop within 1-6 hours of exposure. More severe gastrointestinal symptoms such as persistent vomiting, dehydration, and possible renal and hepatic failure may occur within 10 hours.[2] Parenteral (injection) administration of ricin may be associated with flu-like symptoms, pain, and possibly local necrosis of muscles at the site of injection.[2] A parenteral ricin situation would be limited to one (or a few) individuals and would not merit a public health response. Death may occur in severe cases by all of these routes of administration within 36-72 hours. Aside from supportive care, there currently is no treatment for ricin intoxication, although there are some vaccines presently in development and clinical trials (see Chapter 6).

In the "Fallen Angel" case, the ricin was discovered in a visible powder form. In November 2004, several government agencies (FBI, DHS, HHS/CDC) promulgated general guidelines for five scenarios that involve a combination of the presence or absence of suspicious powders/containers, threats, sick persons, and unusual packages. The following is a general grouping of these suggestions, which all aim to avoid actions or conditions that may aerosolize the material in question:[3]

- Do not touch, move, or open any suspicious packages
- Isolate suspicious packages
- Request assistance from nearest hazardous materials (HAZMAT) response team
- Notify the appropriate law enforcement entities (and U.S. Postal Service, if the situation involves the mail)
- Make a list of persons in the vicinity of the powder
- If appropriate, FBI will conduct a threat assessment and if deemed necessary, samples will be sent to a CDC-qualified Laboratory Response Network (LRN) laboratory.

A recent General Accounting Office (GAO) report analyzes the South Carolina mail facility ricin incident and offers additional recommendations regarding treatment of suspicious mail.[4] This report can be accessed at: http://www.gao.gov/new.items/d05716.pdf.

2.2 Preliminary Assessment to Determine Credible Threat

In a situation in which there is a bulk container or sealed container of powder, a HAZMAT unit may take field samples with a testing device called a Hand Held Assay (HHA). A small amount of a suspicious powder will be dissolved in buffer, which in turn can then be applied to a ticket test that may react with a panel of biological agents (see Chapter 4 for a more complete account of these tests and procedures). Due to the lower sensitivity and higher rate of false positives compared to LRN testing, CDC does not support the use of HHA for field testing. However, many local jurisdictions may use this form of initial testing. A positive result will be sent to an LRN laboratory for more comprehensive and definitive tests. Testing conducted at an LRN laboratory is the gold standard for confirmation of ricin.

2.3 Notification and Initial Actions

The Biological Incident Annex of the NRP clearly spells out the actions, roles, and responsibilities associated with a response to a biological agent or a disease outbreak requiring Federal assistance.[6] However, the NRP applies only to events that are designated as Incidents of National Significance. This can occur with or without a Presidential Stafford Act declaration or a Public Health Emergency declaration by the HHS Secretary. Many "white powder" incidents occur every day, and it is likely that most will not rise to the level of being declared an Incident of National Significance.

If a ricin incident occurred, it would be extremely unlikely that this would be a natural event. Thus, any ricin incident should be treated as a terrorist/criminal incident until proven otherwise. This requires that the FBI be notified, who would in turn notify the Department of Homeland Security (DHS) Operations Center (HSOC). This document is concerned with the public health and medical response to a ricin incident; however, the Terrorism Incident Law Enforcement Annex of the NRP provides additional information on the FBI's role in pursuing the investigative response to a terrorist event.

The responding HAZMAT team should also notify local public health and emergency management officials through local procedures. Local public health officials should notify CDC, who in turn will notify HHS headquarters. HHS and the National Response Center (NRC), staffed by United States Coast Guard personnel, should also receive notification via the HSOC.

The Dirksen Senate Office Building ricin incident was unique in that it occurred in the Senate, a building of the Legislative branch, which is under the jurisdiction of the U.S. Capitol Police.[5] That event occurred in February 2004, before the NRP was formally published, thus the response did not follow the path now laid out in the NRP for

Executive branch agencies. Regardless of where the incident occurs, HAZMAT first responders should notify the appropriate agencies.

Notification phone numbers

Agency	Entity	Phone Number	Email
FBI	Local office	see http://www.fbi.gov/contact/fo/fo.htm	
DHS	HSOC	202-282-8101	HSCenter@dhs.gov
HHS	SOC	202-619-7800	HHS.SOC@hhs.gov
CDC	Emergency response hotline	770-488-7100	
NRC	Emergency response hotline	202-267-2675	lst-nrcinfo@comdt.uscg.mil

2.4 Roles and Responsibilities

State and local agencies have the primary responsibility for response to a ricin incident and will most likely be the first responders. The table below outlines the roles and responsibilities of Federal agencies that may be involved in the response to a ricin incident. These responsibilities are delineated in the NRP, National Contingency Plan (NCP), and agency legal authorities.

Roles and responsibilities of Federal agencies in a ricin response

Agency	Role	Types of activities/support	Sources
DOJ/FBI	Law enforcement and investigative response	Criminal investigation of terrorist acts or threats	NRP, HSPD-5
HHS	Public health and medical response	Public health risk assessment; recommendations to mitigate situation; victim decontamination, sampling, analysis, and monitoring for medical diagnosis; epidemiological investigation; medical care; medical equipment and supplies	NRP
EPA/USCG*	Environmental decontamination and cleanup	Sampling, analysis, and monitoring for site characterization and cleanup verification; removal and remediation activities; waste and debris management	NRP, NCP
OSHA	Worker health and safety	Decontamination and assurance of safe working conditions for responders and cleanup workers	NRP
USDA	Agriculture and animal response	Agriculture, food, and animal decontamination and waste disposal	NRP

* EPA is the lead for the inland zone and USCG is the lead for the coastal zone, except at Federal facilities. DOD/DOE are the leads for incidents involving their respective facilities, vessels, and materials.

2.5 Coordination of the Response

HHS is the lead Federal Government agency for the public health response to a biological incident. Regarding Federal, State and local responsibilities, the Biological Incident Annex states:

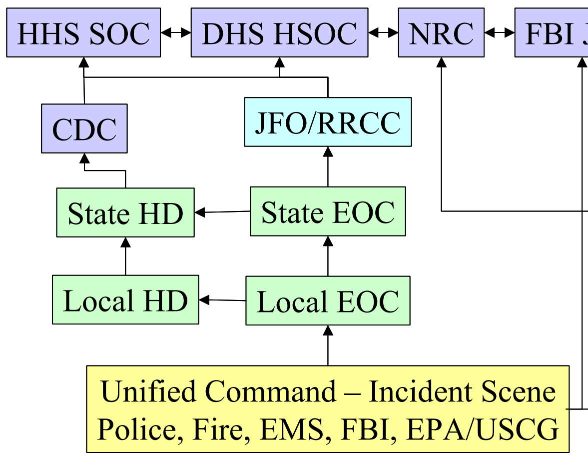
> "HHS serves as the Federal Government's primary agency for the public health and medical preparation and planning for and response to a biological terrorism attack or naturally occurring outbreak that results from either a known or novel pathogen, including an emerging infectious disease. State, local, and tribal governments are primarily responsible for detecting and responding to disease outbreaks and implementing measures to minimize the health, social, and economic consequences of such an outbreak."[6]

Whether or not a ricin incident is an Incident of National Significance,[a] Federal agencies support the State and local response under existing authorities, such as the Public Health

[a] The NRP defines Incidents of National Significance as meeting one of the following four criteria: a Federal department or agency acting under its own authority has requested the assistance of the Secretary of Homeland Security, the resources of State and local authorities are overwhelmed and Federal assistance has been requested by the appropriate State and local authorities, more than one Federal department or agency has become substantially involved in responding to an incident, or the Secretary of Homeland Security has been directed to assume responsibility for managing a domestic incident by the President.

Security and Bioterrorism Preparedness and Response Act of 2002, Comprehensive Environmental Compensation and Liability Act, National Oil and Hazardous Substances Pollution Contingency Plan, Public Health Service Act, and Occupational Safety and Health Act. Communication and coordination of the response occur through the entities, coordination centers, and incident command shown below (see Glossary for acronym definitions).

Communication and coordination during a ricin incident



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[1]"Toxin Found in Envelope at S.C. Post Office," Available at: <http://www.cnn.com/2003/US/10/22/ricin.letter/index.html>
[2]NIOSH Emergency Response Card: Ricin. February 18, 2004. Available at: <http://www.bt.cdc.gov/agent/ricin/erc9009-86-3.asp>
[3]*Guidance on Initial Responses to Suspicious Letter/Container with Potential Biological Threat,* November 2, 2004, FBI-DHS/HHS/CDC Coordinated Document.
[4]GAO-05-716 *U.S. Postal Service: Guidance on Suspicious Mail Needs Further Refinement*, July 2005.
[5]McCue B, et al., Dirksen Building White Powder Incident After-Action Report on Medical and Public Health**,** CNA Corporation, Alexandria VA, IPR11089, August 2005.
[6]Biological Incident Annex, National Response Plan, December 2004, Department of Homeland Security.

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3.0 Response Worker Health and Safety

This chapter provides an overview of health and safety considerations for workers and other individuals potentially exposed to ricin. The following key actions should be taken during a ricin incident; each is described in more detail in this chapter:

- Develop a Health and Safety Plan (HASP) in accordance with Occupational Safety and Health Administration (OSHA) regulations.
- Develop a site-specific training program.
- Use appropriate personal protective equipment (PPE) for ricin (as described in the following table).
- Establish a medical surveillance program for site workers.

Ricin-specific Personal Protective Equipment Recommendations	
NIOSH[1]	**For inhalation:** Pressure demand, self-contained breathing apparatus (SCBA) (SCBA CBRN, if available) is recommended in response to non-routine emergency situations. In other situations, two types of full face-piece, tight-fitting masks may be used: 1) Powered Air Purifying respirator (PAPR) with HEPA filters; or 2) Air Purifying respirator (APR) with P100 filters. **For skin:** Tychem® BR or Responder® CSM protective clothing. Eyes should be protected when possible. **For eyes:** Full face-piece respirator provides eye protection.
EPA[2]	Initial Hazard evaluation entry in Level B, downgrade to Level C PPE with full face-piece APRs or PAPRs (HEPA P-100 Chlorine Combo cartridges because of decon solution). Inner Suit: Tyvek®, Outer Suit: Saranax or equivalents.
CDC recommendations for those decontaminating victims[3]	Full polyethylene suit with gloves, surgical mask, and eye/face protection (face shield and goggles)
Special considerations	– Airborne dispersal of ricin during decontamination is a potential hazard and would depend upon the size of particles in the particular ricin preparation – Additional barriers (such as double and triple booting) may be required to reduce tracking, avoid cross contamination, and preserve the scene – If chlorine-based decontamination solution is being used, workers will need to add a chlorine cartridge to PPE – Excessive PPE poses other dangers and selections should be based on a site-specific job hazard analysis

Response Checklist	
❑ Develop a Health and Safety Plan (HASP) for cleanup operations	Responsibility of Safety Officer within the Incident Command System
❑ Establish a site-specific training program	Based on HASP hazard analysis
❑ Establish a medical surveillance program under the supervision of a licensed physician	Include medical measures to prevent ricin intoxication, medical screening and follow-up care for ricin and exposure, and knowledge and information that workers need to recognize symptoms of ricin intoxication

3.1 Overview

The purpose of this chapter is to provide an overview of health and safety considerations for workers and other individuals potentially exposed to ricin, particularly aerosolizable ricin. These include both short-term response workers (e.g., emergency medical personnel, police, and firefighters) and long-term response workers (e.g., environmental response team members and decontamination workers). Certain elements of this chapter also apply to non-responders such as occupants, employees, or visitors at a site potentially contaminated with ricin. Ricin-induced toxicity occurs primarily through inhalation or ingestion, so we will exclude parenteral administration in the discussion of personal protective equipment (PPE).

Response workers should already be covered by a medical program that is part of a broader occupational health and safety program. For example, emergency medical personnel, police, and firefighters are covered by occupational health and safety programs specific to their duties, some of which may involve response to hazardous material incidents. Hazardous waste operations and emergency response workers are covered by OSHA's Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) standard. However, typical medical programs for responders do not address medical considerations specific to ricin.

The medical program for response to ricin should be designed and administered under the supervision of a licensed physician in conjunction with a Health and Safety Officer. The supervising physician should be knowledgeable about all of the relevant areas of occupational medicine (e.g., toxicology, industrial hygiene, medical screening, and occupational health surveillance) and should be able to appropriately interpret and use information about potential exposures, PPE, work schedules, work practices, and relevant regulations. In addition, this physician should be specifically knowledgeable about the toxicity of ricin and its clinical manifestations.

As in any emergency situation, work sites for long-term response workers may be far from the home-base or permanent duty station. Healthcare providers implementing the program should be selected for accessibility to workers, diagnostic resources, a reliable system for hospital referral, and around-the-clock coverage for work-related medical care. The supervising physician should be routinely informed about non-emergency matters and contacted immediately for high-dose exposures, medical emergencies, and any issues not covered in the provider's contract. Release of information for occupational health and safety purposes is subject to legal requirements for confidentiality. For example, confidentiality of medical information should be maintained when notifying an employer of an individual worker's fitness for duty. Each worker should be notified of the results of his or her own evaluation. Employers and workers should be informed of group findings and related recommendations.

Worker health and safety is usually implemented within the context of the Incident Command System, where a Safety Officer is assigned and is responsible for the set of systems and procedures necessary to ensure ongoing assessment of hazardous environments, coordination of multiagency safety efforts, and implementation of measures to promote emergency responder safety, as well as the general safety of incident operations.[4]

3.2 Health and Safety Plans

With rare exceptions (i.e., when OSHA does not have jurisdiction), OSHA's HAZWOPER standard (29 CRF 1910.120) applies to each of the employers of the workers involved in a ricin-related response (e.g., agencies employing emergency responders, decontamination contractors, employers at the contaminated facility, government agencies providing oversight and assistance). For cleanup operations, this standard requires a written Health and Safety Plan (HASP), which identifies site hazards and appropriate controls to protect employee health and safety. The HASP also requires documentation of all pertinent data and sources of technical information.

Unlike anthrax (http://www.osha.gov/dep/anthrax/hasp/index.html), there are currently no specific OSHA Standards or Directives for ricin. The elements of a HASP typically include the following:

- Organizational Structure
- Job Hazard Analysis
- Site Control
- Training Program
- Medical Surveillance Requirements
- Personal Protective Equipment (PPE)
- Exposure Monitoring
- Thermal Stress
- Spill Containment Program
- Decontamination Program
- Emergency Response Plan
- Standard Operating Procedures
- Confined Space Programs
- Hot Work (e.g., welding, cutting, heating)
- Lockout/Tagout (practices and procedures necessary to disable machinery or equipment and to prevent the release of potentially hazardous energy while maintenance and servicing activities are being performed).

In general, a site plan is organized as a single document, with component sections and appendices covering all tasks, operations, and contractor/subcontractor issues. A site plan also promotes efficiency and enhances completeness, clarity, and coordination among all affected parties.

An electronic template for preparing a HASP can be found at http://www.osha.gov/dep/etools/ehasp/index.html. Due to overlap of some of the elements, it may be useful to expand the HASP to include those elements necessary to protect the local community and environment (e.g., disposal of waste from decontamination, monitoring community exposures to fumigants).

For additional information, see http://www.osha.gov/SLTC/ricin/standards.html.

3.3 Appropriate Health and Safety Training

A site-specific training program ensures that workers receive the hazard awareness training they need to work safely. Training should be based on the job hazard analysis in the HASP and other applicable standards, such as those listed below.

3.3.1 Emergency response

The five levels of training for employees who initially respond to an emergency are listed below from the lowest to highest level of competency.

- First Responder awareness level
- First Responder operations level
- Hazardous Materials Technician
- Hazardous Materials Specialist
- On-scene Incident Commander.

Each level requires employers to have sufficient training or to have sufficient experience to objectively demonstrate competencies listed in 29 CFR 1910.120(q)(6). Certification of training is required.

3.3.2 Healthcare workers

Healthcare workers risk occupational exposures to ricin when a healthcare facility receives contaminated patients, particularly during mass casualty incidents. These healthcare facility employees, who may be termed *first receivers*, work at a site remote from the location where the hazardous substance release occurred. This means that their exposures are limited to the substances transported to the healthcare facility on victims' skin, hair, clothing, or personal effects. If there is no trauma or exposure to other agents (this may be unknown), there may be reduced urgency in transporting ricin-exposed patients to a healthcare facility since there are no urgent medical interventions, allowing more time for a more thorough decontamination of patients prior to transport. The location and limited source of contaminant distinguishes first receivers from other first responders (e.g., firefighters, law enforcement, and ambulance service personnel), who typically respond to the incident site (i.e., the Release Zone).

OSHA Best Practices for Hospital-Based First Receivers of Victims from Mass Casualty Incidents Involving the Release of Hazardous Substances (http://www.osha.gov/dts/osta/bestpractices/html/hospital_firstreceivers.html) provides training and best practices information for healthcare workers.

3.3.3 Cleanup operations

At sites where OSHA's HAZWOPER standard applies, the safety and health training program should be based on the job hazard analysis in the HASP and other relevant OSHA requirements. The training elements required by HAZWOPER include the following:

- Initial hazard awareness training for site workers and supervisors
- Exceptions to initial training requirements
- Site-specific hazard awareness briefings for visitors and workers
- Refresher training
- Qualification of trainers
- Training certification
- Emergency response training.

All employees who work on a HAZWOPER cleanup site (not limited to cleanup crew) where they are exposed to hazardous substances, health hazards, or safety hazards, must have training that meets the requirement of 29 CFR 1910.120(e) or have equivalent experience and/or training. The four levels of training for employees who work on cleanup operations are listed below:

- General site workers
- Workers on site only occasionally for a specific limited task (unlikely to be exposed over limits and not required to wear respirators)
- Workers regularly on site in monitored and fully characterized task areas (unlikely to be exposed over limits and not required to wear respirators)
- Managers and supervisors.

Each level requires employees to have sufficient training or to have equivalent experience. Certification of training is required. The required elements of training are:

- Names of personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on the site
- Use of PPE
- Work practices by which the employer can minimize risks from hazards
- Safe use of engineering controls and equipment on the site
- Medical surveillance requirements including recognition of the symptoms and signs that might indicate exposure to hazards
- Contents of the site safety and health plan including the following:
  - Decontamination procedures in accordance with 29 CFR 1910.120(k)
  - An emergency response plan meeting the requirements of 29 CFR 1910.120(l) for safe and effective responses to emergencies including the necessary PPE

and other equipment
- Confined space entry procedures
- A spill containment program meeting the requirements of 29 CFR 1910.120(j).

3.3.4 Post-emergency cleanup

Where the cleanup is done on plant property using plant or workplace employees, these employees must have completed the training requirements of the following:

- Emergency action plan 29 CFR 1910.38(a)
- Respiratory protection 29 CFR 1910.134
- Hazard communication 29 CFR 1910.1200
- Other appropriate safety and health training made necessary by the tasks that are expected to be performed (e.g., PPE and decontamination procedures).

3.3.5 Site-Specific safety and health training

A site-specific training program ensures that workers receive the training they need to work safely. Workers must receive all training required by applicable OSHA standards. This training may be included in the HAZWOPER curriculum. Examples of relevant training required by other standards include the following:

- Hazard communication
- PPE
- Respiratory protection
- Fire extinguisher
- Emergency action plan
- Fire prevention plan
- Emergency response
- Lockout/tagout
- Observing working surfaces
- Noise.

Ricin-specific hazard awareness training should help workers understand the health hazards of ricin and how to protect themselves from exposure. Specific topics might include the following:

- How workers might be exposed to ricin, the signs and symptoms of poisoning, and medical conditions that could place them at increased risk (e.g., compromised immune systems)
- What kinds of sampling and analysis will be or have been performed, including a general description of the sampling objectives (e.g., qualitative screening versus verification) and the limitations of the methodologies used
- An explanation of available sampling results, including the types of sampling performed, where contamination has been identified in the facility, and the status

of decontamination of those areas

- How to minimize the risk of exposure through specific standard operating procedures and controls (e.g., engineering controls, work practices, housekeeping, or PPE), and whether specific measures are expected to be temporary or permanent.

There are additional training requirements for workers preparing contaminated materials or other hazardous materials for transportation to an analytical laboratory or treatment/disposal facility. These requirements can be found in the Federal hazardous materials transportation regulations at 49 CFR Part 172, Subpart H.

3.4 Personal Protective Equipment (PPE)

PPE shields or isolates workers from health and safety hazards in the workplace. In a site where ricin may be present, PPE protects workers from exposure to respiratory and skin hazards and prevents the spread of contaminants to uncontaminated areas. PPE can also be used to protect workers from additional hazardous substances such as those being used for the decontamination process. However, PPE is not a substitute for sound engineering, work practice, or administrative controls. PPE complements these controls to protect employee health and safety in the workplace.

Personnel entering an area known or suspected to be contaminated with ricin must wear the appropriate level and type of PPE. The level and type of PPE should be based on the job hazard analysis in the HASP. Use of excessive PPE may actually increase a worker's risk of injury or illness through heat stress, accidents caused by tripping or limited vision, and difficulty communicating with other workers. Because conditions vary from site to site, specific PPE requirements should be specified by the Incident Commander and outlined in the on-site HASP. Additional information regarding hazard assessment and PPE selection is provided in 29 CFR 1910.132, available at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10120.

Workers should be trained to know when PPE is necessary, what type to use, how it should be worn, what its limitations are, and how long it is likely to last. They should also know how to properly maintain and dispose of it. If more than one type of PPE will provide adequate protection, employers may choose the type they prefer. Employers should certify in writing that the training has been provided and that employees understand what they need to know about PPE. The certification should show the name of each employee trained and the dates and types of training provided.

In addition, appropriate personnel decontamination and contamination containment procedures are needed for workers using PPE to prevent exposure to ricin. In general, these procedures are similar to those for asbestos abatement and include isolating contaminated areas, negative pressure ventilation, a three- or five-stage decontamination line with a shower for equipment and personnel, and appropriate waste disposal. For additional information, see EPA's publication *Guidance for Controlling Asbestos-Containing Materials in Buildings*.

Despite the use of PPE, response workers may be at risk for exposure to ricin because PPE is not 100% protective, work practices may be inadequate, and breaches in PPE and environmental controls may occur.

There are very few countermeasures available for treating ricin exposure (see chapter 6 for more information). If the exposure is aerosol, and response workers have a breach in their respirator, or if it is powder and there is a breach in skin protection, the workers must be placed in the "exposed" category and monitored closely, educated, and reassured.

3.4.1 Skin protection

Wearing protective clothing not only protects the skin but also can prevent the transfer of contamination off-site. Based on the conditions at the site, the Incident Commander or the site Health and Safety Officer should determine the appropriate level of skin protection, which should also be outlined in the HASP. Tyvek® or equivalent coveralls should be used as a minimum level of protection. Ricin toxin does not easily permeate the skin, thus while skin contact is undesirable, it does not in itself pose a great risk for toxicity. Washing with soap and water should remove most (ricin) protein from the skin. It addition to protection from contact with ricin, PPE must also protect the worker from contact with chemicals used in the response.

Unpowdered disposable gloves made of lightweight nitrile or vinyl protect the hands. A thin cotton glove may be worn inside a disposable glove to protect against dermatitis, which may occur from prolonged exposure of the skin to moisture caused by perspiration.

EPA recommendations for workers responding to a ricin incident are (1) Tyvek® inner suit, and (2) outer suit of Saranax or equivalent material.[2]

Preventing droplets from contacting broken skin or mucosal membranes (e.g., the mouth or eyes) is important when decontaminating someone or cleaning up body fluids that may contain toxin. CDC recommendations for those who are decontaminating victims who arrive at a hospital without having been adequately decontaminated are the following:[3]

- Full polyethylene suit with gloves, surgical mask, and eye/face protection (face shield and goggles)
- After completing decontamination tasks, removal of all PPE followed by a shower.

3.4.2 Respiratory protection

Since airborne particles may pose the greatest threat to personnel, respiratory protection is a necessary component of the PPE program. The OSHA respiratory protection standard

(29 CFR 1910.134) requires that employers establish and maintain an effective respiratory program and that employees must comply with the program. Requirements include program administration, worksite-specific procedures, respirator selection, employee training, fit testing (e.g., with irritant smoke), medical evaluation, and respirator use, cleaning, maintenance, and repair.

There may be cases where the use of respirators is desired by workers but not required for adequate protection. This voluntary use is allowed but it is subject to requirements under OSHA's respiratory protection standard (29 CFR 1910.134).

EPA recommendations for workers responding to a ricin incident are the following:[2]

- Initial hazard evaluation entry in Level B
- Downgrade to Level C PPE with full face-piece APRs or PAPRs (HEPA P-100 Chlorine Combo cartridges because of decon solution).

Airborne dispersal of ricin during decontamination is a potential hazard and depends on the size of particles and other physical characteristics and properties in the particular ricin preparation. CDC recommendations for those who are decontaminating victims who arrive at a hospital without having been adequately decontaminated were stated above.

During the response to the Dirksen Senate Building Ricin incident in 2004, Level C was deemed to be sufficiently protective against the risk based on a solid exposure assessment, given the non-aerosolized form of the ricin and its most likely toxic routes of exposure (inhalation).[5]

3.5 Medical Program

In addition to medical surveillance programs required in the HAZWOPER and respiratory protection regulations, the occupational health and safety plan should include the following three major components:

- *Medical measures to prevent ricin intoxication:* There are no antibiotics, antitoxins, or vaccines currently available to prevent symptoms in those already exposed. Therefore, in ricin exposure tracking, education and close monitoring are extremely important to ensure access to supportive medical care early in the course of a poisoning.
- *Medical screening and follow-up care for ricin and exposure:* The care of exposed workers consists of careful history, targeted examination, and education. It is essential to classify workers into four categories: definitely exposed, likely exposed, possibly exposed, and definitely not exposed. The employer (or their medical department if one exists) should have a plan for each of these categories such as admission and monitoring for definitely exposed, symptom education and self-monitoring with periodic screening for likely and possibly exposed, and reassurance and counseling for definitely not exposed.
- *Knowledge and information that workers need to recognize symptoms of ricin intoxication:* As the symptoms can take several hours to a day to develop, even

after high degrees of exposure, this clinical information is essential for all workers. Employers also must be alert to the psychological effects on workers when a terrorist attack occurs at their workplace.

3.5.1 Medical screening, monitoring, and follow-up care

The purpose of occupational health surveillance in the workplace is to improve the effectiveness of the occupational health and safety program by systematically collecting and analyzing information that pertains to at-risk workers. Examples of useful information include the results from a medical screening program, a medical monitoring program for adverse work-related health effects, and exposure monitoring (e.g., incidents of breaches in PPE). Such information should be provided in a timely manner to the supervising physician for analysis and interpretation. The results of occupational health surveillance can be used to determine the need for additional screening or other precautions needed to protect worker health and safety. This kind of surveillance can also help assess the adequacy/effectiveness of the precautions in place.

Medical screening is the use of examinations or tests to detect adverse effects on a worker's health at an early stage when prevention is possible or treatment is most effective. Baseline medical screening should identify pre-existing conditions that may affect an individual worker's fitness for duty. The physical demands of the work and the PPE selected should be considered, as well as potential health effects (e.g., heat stress, dehydration, claustrophobia, and aggravation of heart, respiratory, and skin conditions). Workers should be evaluated periodically to reassess fitness for duty. When it is no longer necessary for a worker to re-enter a contaminated site, a final evaluation should be done to identify changes from the baseline and any new risk factors.

Taking a careful history is the most important factor in determining whether a person has been exposed: what type of exposure occurred, where they were, what were the ambient conditions, what were the effects on co-workers in the regions, what symptoms are they having, what is their past medical history (to detect co-morbidities), and the like. Immunological tests can be performed on secretions and serum, and if there is a question of exposure, samples should be collected after education and obtaining informed consent. Each workplace needs to develop a plan for collecting, interpreting, and responding to these acute and convalescent clinical samples.

OSHA does not have specific standards or limits for ricin. The only published Occupational Exposure Limit is for ChemWatch – Ceiling 0.00006 (sensitizer) mg/m^3.[1]

3.5.2 Knowledge and information

HAZWOPER training requirements are described above in Section 3.2. Response workers will also need additional knowledge and information about ricin and the preventive measures that can protect them (early symptom recognition, screening and monitoring). All response workers should be trained to recognize and report early symptoms and signs of ricin exposure, understand the importance of immediate medical attention, and know how to access emergency medical care.

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4.0 Sampling and Laboratory Analysis

This chapter discusses the sampling and laboratory issues that should occur in a response to a possible event involving ricin toxin. Major points encapsulated in this chapter are:

- Ricin is a toxin that can be extracted from castor beans. The ricin protein consists of an A and B chain. The B chain binds to cell surfaces allowing intracellular incorporation of the A chain, which enzymatically depurinates ribosomes that are active in protein synthesis.
- The three primary routes of administration of ricin are inhalation, ingestion, and injection. The effects of ricin poisoning depend on the route of administration and the dose received.
- Ricin is not a contagious agent and no antidote exists for it.
- The sampling and laboratory response will involve public health laboratories, law enforcement, and environmental agencies.
- Field-testing for ricin is not definitive and samples must be processed at a LRN (or equivalent) laboratory. There are several types of laboratory tests to identify ricin; the gold standard test is the immunoassay.

4.1 Background

4.1.1 Preparation of ricin toxin

Ricin is a 66-kilodalton protein that can be purified from the castor bean (Latin name *Ricinus communis*) in a relatively simple process that requires several separation and precipitation steps using commonly available chemicals, including sodium hydroxide and acetic acid. Most of this information is readily available from open-source scientific literature, and purification of ricin toxin to near homogeneity is certainly achievable by a person with some biochemistry laboratory experience and access to standard laboratory equipment.

4.1.2 Physical properties

Ricin is a grayish-white water-soluble powder. It is a non-contagious agent and can be potentially administrated through such routes as inhalation, ingestion, or injection. Ricin is non-volatile, but a stable aerosol could be formulated. Ricin is stable under room temperature conditions but is deactivated by heat (176 ºF/ 80 ºC for one hour) *in vitro* for aqueous media. As demonstrated by earlier experiments carried out by the military, 98% inactivation is achieved after this treatment.[1] Ricin can persist in soil or a cool, dry environment for approximately three days (as described in World War II studies).[2]

4.1.3 Mechanism of action

Ricin inactivates ribosomes, shutting down protein synthesis and leading (in sufficient doses) first to death at the cellular level, then to tissue damage, and finally to multi-organ dysfunction and organism death. The ricin protein consists of an A and B chain. The B chain binds to cell surfaces allowing intracellular incorporation of the A chain, which enzymatically depurinates ribosomes that are active in protein synthesis.

4.2 Exposure testing

With regard to exposure testing, the US Army Medical Research Institute of Infectious Diseases (USAMRIID), recommends that if possible, early post-exposure samples (0-24 hours) such as nasal swabs and induced respiratory secretion samples should be collected for polymerase chain reaction (PCR) and toxin assay testing, and serum samples should be collected for toxin testing. At 36-48 hours post-exposure, there should be collection of serum for a toxin assay and tissues from pathology samples. At more than 6 days post-exposure, serum should be collected to detect the presence of anti-ricin IgM and IgG antibodies in survivors.[8] These tests are briefly described in this chapter.

The CDC notes that the validity of nasal swabs as a clinical tool is not fully established.[9] There are guidelines from CDC regarding packing and shipping instructions of clinical samples (blood, urine) from persons potentially exposed to a chemical terrorism agent.[10] CDC can currently test for the alkaloid ricinine in urine. Ricinine is a separate chemical contained in the castor bean plant along with the ricin protein. The presence of ricinine in a sample may indicate exposure to ricin, if the ricin-containing material is not highly purified. CDC also is developing a method for detection of ricin in biological samples based on peptide sequence recognition using mass spectrometry.

4.3 Field sampling: collection, preparation, packaging, and transport

It is important that first responders work in conjunction with law enforcement officials, as collected samples may become evidence in a criminal prosecution. As described in the Biological Incident Annex of the NRP, once a threat is defined to be real, the FBI will send the samples to a member laboratory of the LRN.[11] If a sample tests positive for ricin at a reference laboratory, it may be sent to CDC or other appropriate laboratory for additional testing, defining, archiving, or storage.

It may be useful to draw from previous ricin incident protocols to describe how sampling for a future event might take place. In October 2003, when a vial containing ricin was discovered in a South Carolina mail facility, the CDC conducted environmental sampling and an assessment of the facility. Seventy (70) wipe samples were collected using Dacron swabs moistened with sterile buffer from items such as storage bins, surfaces, conveyor belts, and sorting tables that had been in contact with the letter containing the vial. Five surface dust samples were collected by sampling pumps and sampling filter media. All of these environmental samples tested negative for ricin.[12] The material inside the vial did test positive for ricin.[13] Defined protocols are needed for surface and air sampling, and there currently are no specific OSHA Standards or Directives for ricin.[14] The EPA has been tasked with determining their own standards for reoccupancy of a building after a ricin event, as no specific EPA standards exist for ricin at present.

Surface samples can be physically taken with dry or wet (with buffer) wipes and swabs and for larger-area samples, collected with a high volume vacuum with a High Efficiency Particulate Air (HEPA) sock. Direct removal of a bulk sample, such as a letter or a vacuum bag to a laboratory may also be appropriate.[15] If Dry Filter Units are present in a building where a "white powder" incident occurs, the filters should be collected and processed by an appropriate laboratory. Wipe sampling of an HVAC (heating, ventilation, and air conditioning) system may give an indication of whether the air pathway should be considered as a possible pathway.[16] One of the main goals of airborne sampling is to try to collect data on the physical parameters of the agent (particle size and number) and to characterize the atmosphere of the contaminated area.

The extent and location of contamination (site characterization) can be determined by either a targeted or statistical-based sampling strategy.[15] Any information regarding delivery and/or dissemination of the ricin in the particular incident would tend to favor the targeted strategy.

Many first responders, including the U.S. Capitol Police in the case of the 2004 Dirksen Senate Building ricin incident, use Hand Held Assays (HHAs) as the first field test for a biological agent. HHAs are used primarily by first responders for public safety purposes to determine whether there may be a specific biological threat present; these assays are not intended for clinical samples. It is important to note that the CDC does not support the use of HHAs for field testing. The majority of any powdered material should be preserved for public health laboratory and criminal investigative requirements.

"Environmental sampling" can be categorized as the sampling that is performed once the agent and its characteristics have been determined and should be supportive of, but separate from, the forensic and clinical focus. Specifically, environmental sampling focuses on identifying the extent of contaminant spread to ensure that adequate cleanup design is implemented and then verified. This will be discussed in later chapters of this document.

While sampling is an important tool, certain limitations must be kept in mind. Currently, there are no occupational or environmental exposure standards for ricin contamination and no validated sampling and analytical methods specifically for ricin in environmental samples. There are also still insufficient data on the collection efficiency of various sample collection media (e.g., swabs, wipes, filters) for typical surfaces encountered in indoor environments (e.g., furniture, carpet, letters, clothing, computer screens, ventilation system filters).

4.4 Sample handling and transport

With regard to sample packaging, guidelines should be followed to preserve the integrity of the sample (i.e., prevent leakage), to clearly document what form the sample is in and where it was collected from, and to withstand possible rough handling during transport. Chain of custody forms should be appropriately filled out as the sample is passed from one handler to another (i.e., first responder to law enforcement official or laboratory technician).

Sample collection, preparation, and transport are all integral to the response to a biological event. However, it is important to realize that these actions involve different jurisdictions (law enforcement, public health, environmental) with overlapping missions. The initial sample collection should be coordinated with destination lab protocols if possible. The samples should be taken to a laboratory that is a member of the LRN, and packaging of the samples should agree with LRN requirements. In a suspected bioterrorism event, these samples are transported by law enforcement (either local or

FBI) and a scrupulous chain of custody protocol for the samples must be maintained in order not to compromise future criminal prosecution efforts.

4.5 Analytical Methods

It should be noted that ricin is a protein with heterogeneous variants of glycosylation (N-linked). This may affect the identification of ricin by certain techniques.

4.5.1 Immunoassay

Immunoassay is the gold standard test for ricin detection. In this type of test, antibodies bind specifically to the agent of interest. A "capture" antibody is immobilized on a filter, support, or plate. Then the sample is introduced onto the plate, and if the agent is present, it binds to the immobilized antibody. A secondary "reporter" antibody coupled to a label that may be fluorescent, chemiluminescent, or radioactive is added after the sample, and binds to the antigen of interest if it is present in the sample in a detectable amount. It is important to note that a particular immunoassay's sensitivity may depend on how much antibody is present, what kind of antibody (polyclonal or monoclonal) is immobilized, and the type of label used for detection. One immunoassay test is ELISA, Enzyme-Linked Immunosorbant Assay. Another type is the Western blot, which immobilizes the antibody on a filter instead of a plate.

A time-resolved fluorescence (TRF) immunoassay is used by CDC and the LRN laboratories as the gold standard for ricin detection.[17] This assay cannot be used on certain environmental samples because environmental lanthanide can give false positives in this assay. Other laboratories use different immunoassay probes. The Naval Medical Research Center (NMRC) used an antigen capture ELISA to detect the presence of ricin in the 2004 Dirksen Senate Building samples. The antigen was visualized by a horseradish peroxidase-linked secondary antibody in this particular assay. To give a sense of the sensitivity of some of these assays, the detection level for the NMRC assay was 200 picograms (pg) ricin/milliliter (ml).[18] USAMRIID uses electrochemiluminescence (ECL)-based immunoassays, with sensitivity (LOQ) in the range of 100 pg/ml.[19]

4.5.2 Polymerase chain reaction (PCR)

PCR amplifies DNA from a very small (nanogram or smaller) starting amount of sample, utilizing a thermostable enzyme (DNA polymerase). Traditional PCR is done using tailored *primers*, targeted to specific genes in a given DNA sample. These primers attach to their specified genes—if present in the sample—and (powered by adenosine tri-phosphate (ATP) and nucleotides) create a chain reaction resulting in many copies of the DNA strand beginning and ending with these specific genes. The presence of these copies can then be visualized by the presence of a PCR product of the right length on an agarose gel and if necessary, be sequenced to verify that the PCR product is indeed the target of interest. “Real-time” PCR is based on detection of a fluorescent signal produced proportionally during amplification of a PCR product[20] and can measure the kinetics at an early exponential phase of the reaction, eliminating the need to run an agarose gel for end point detection of the PCR product.

PCR cannot be considered a gold standard test for ricin, as it cannot detect purified ricin toxin, which is a protein. PCR can detect castor bean DNA present in a sample. The PCR test for ricin is a qualitative test only. It is highly unlikely that there will be a constant amount of DNA contamination in all ricin samples, so no relationship can be drawn between the amount of DNA and the amount of ricin. Further, the presence of castor bean DNA alone cannot confirm the presence of ricin.[20] PCR is an extremely sensitive test, which only takes a few hours to complete, and should be performed in conjunction with an ELISA when a ricin event is suspected. Usually multiple gene targets in the *Ricinus communis* genome would be amplified to provide redundant verification of a positive result. The NMRC protocol used both the A and B chains of ricin as their gene targets for their 2004 PCR analysis.[18] The CDC and the LRN currently field their own PCR protocol for ricin.

4.5.3 Bioassay

In the 2004 Dirksen Senate Building ricin incident, NMRC used a cell bioassay system to confirm the presence of active ricin in some of the samples. The presence of ricin toxicity was shown in a flow cytometry assay using human Jurkat cells (derived from human T-cell leukemia). These cells were incubated +/- sample, control ricin, and ricin neutralizing antibodies (which are not available in many laboratories). The toxicity analyses took 4-16 hours to complete. Some Dirksen samples did contain evidence of active ricin, and this activity was specifically blocked by neutralizing anti-ricin antibodies.[18] It is interesting to note that by the time these tests had been performed at NMRC, the ricin had persisted at ambient temperature for at least 72 hours.[21] It is not known how pure the ricin in these samples was; impurities may have contributed to its stabilization. However, assumptions about ricin toxin degradation in the literature may need to be retested and revisited.

4.5.4 Activity assay

USAMRIID performed an activity assay on some of the Dirksen samples. As in the bioassay, the activity assay verifies the presence of active ricin toxin in a sample. This microtiter assay is capable of detecting the ribosome-inactivating activity of ricin toxin at low nanomolar concentrations (0.1 – 0.5 nM, which is equivalent to 10 μg ricin in 1 ml). Ricin activity was quantitated as percent inhibition of protein synthesis in a nuclease-treated rabbit reticulocyte lysate, using luciferase mRNA as a marker. When specific antibodies against ricin were added to this assay, ricin activity was inhibited.[22]

4.5.5 Gas chromatography/mass spectrometry and related methods

Gas chromatography/mass spectrometry separates the components of a mixture and measures the unique mass spectrometric signature of each compound. It can be used to determine whether a component of the sample matches the signature of ricin toxin protein. There have been reported technical difficulties with detecting ricin by gas chromatography/mass spectroscopy (GC/MS). However, ricinine, a toxic alkaloid that is also derived from *Ricinus communis*, may have some use as a marker. The presence of ricinine in a clinical sample would imply exposure to ricin. CDC presently cannot test for ricin directly in biological fluids, but recent literature has suggested methodology for testing for ricinine in urine by mass spectroscopy.[23] A 2005 paper has demonstrated that purified ricin and crude preparations of ricin from castor beans can be successfully characterized by liquid chromatography/mass spectroscopy (LC/MS).[24]

4.5.6 Matrix-assisted laser desorption/ionization time-of-flight mass spectroscopy (MALDI-TOF MS)

Briefly, a biomolecule such as a protein (e.g., ricin) is co-crystallized in an organic matrix and then irradiated with a laser, triggering ionization. The sample is then subjected to mass spectroscopy. In time-of-flight spectroscopy, ions of different masses are separated based on the time needed for the ions to traverse a fixed distance.

Technical difficulties in analyzing crude castor bean extracts for ricin by this technique have been noted, as there are highly concentrated low molecular weight components (< 15 kDa), which inhibit the ionization of higher molecular weight compounds like ricin. In one study, after the crude extract was subjected to molecular weight cut-off filtration (components less than 30 kDa pass through a membrane), ricin was detected by this method.[25] The MALDI spectra for non-proteolytically digested ricin and abrin (a poison derived from a plant called the jequirity pea) are almost identical. Thus, additional identification of ricinine (a toxic alkaloid unique to the castor bean) by MALDI-TOF may help unambiguously identify ricin. Digestion of ricin with trypsin protease into peptides may simplify a MALDI-TOF or LC/MS analysis of a suspected ricin sample.

4.5.7 Electron microscopy (EM)

Electron microscopy (EM) of a suspected ricin sample could possibly help determine purity, potential dispersibility, and provenance of ricin. A certain amount of solid sample would be needed for an EM study of physical properties of a ricin sample.

4.6 Interpretation of Results

Interpreting the results of the laboratory analyses will not be limited to basic scientists. Ideally, a multidisciplinary team of experts drawn from first responders, medical practitioners, basic scientists, public health, and environmental experts will have access to this data to make informed decisions as to how to proceed as the response transitions from the acute to the long-term phase.

4.7 Coordination of Sampling Efforts

The Biological Incident Annex of the NRP outlines the actions, roles, and responsibilities associated with a disease outbreak or biological agent dispersal.[26] The NRP is only activated under certain circumstances (i.e., when an Incident of National Significance is declared). In this case, HHS is the primary agency for the public health and medical response to such a bioterrorism attack. HHS must coordinate with the law enforcement response (FBI) to ensure that the most appropriate public health response runs smoothly in tandem with an uncompromised criminal investigation. From the standpoint of sampling, this means following established protocols of how samples should be collected, maintenance of chain of custody, and samples being sent to validated laboratories (i.e., LRN) under proper escort.

If the NRP is not invoked, HHS (and CDC) may be in support of local and state public health offices, private hospitals, and local and state law enforcement.

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5.0 Post-event characterization and analysis

This chapter provides an overview of the post-event characterization and analysis of a ricin incident. It describes common symptoms associated with ricin poisoning and the progression of disease in those affected. It also walks the reader through some basic steps related to the epidemiological investigation, which local and state public health authorities will lead unless the incident occurs on federal property. CDC case definitions for ricin poisoning are provided, as well as information on surveillance and reporting requirements. Some key points of the chapter include the following:

- Exposure to ricin by inhalation is likely to cause a quicker onset of poisoning and a more rapid progression of illness compared to ingestion, given the same exposure amount.
- Early clinical symptoms of ricin poisoning are non-specific and may be hard to distinguish from a respiratory infection (inhalational exposure) or gastroenteritis (ingestional exposure).
- Persons identified as exposed or at risk of exposure, but who are asymptomatic, should be closely monitored for development of illness or symptoms consistent with ricin poisoning.
- Ongoing surveillance may help identify persons exposed and should include, but not be limited to, poison control centers, hospitals or healthcare facilities, medical examiner, 911 calls, primary care providers, pharmacy and veterinary services.
- Public health officials should work closely with local law enforcement and the FBI to coordinate the epidemiological and criminal investigations.

5.1 Epidemiologic Clues of a Covert Attack

Ricin can be prepared in liquid or crystalline form, or as a dry powder. It is water soluble, odorless, tasteless, and stable under ambient conditions.[1] For ricin to be used as a mass casualty weapon, it would have to be aerosolized as fine particles (less than 5 microns) or added to food or beverage as a contaminant.[2] Thus, the most likely route of exposure to ricin toxin in a major terrorist attack is inhalation or ingestion. While there have been no reported mass casualty incidents involving ricin, it has been used as a weapon in isolated incidents.[3]

The following epidemiologic clues may suggest the covert release of a chemical agent or biological toxin such as ricin:[1]

- An unusual increase in the number of patients seeking care for potential chemical or biological toxin-related illness
- Unexplained deaths among otherwise healthy or young people
- Disease outbreaks of the same illness occurring in noncontiguous areas
- Clusters of illness in people who have common characteristics, such as drinking water from the same source
- Rapid onset of symptoms after an exposure to a potentially contaminated source
- Unexplained death of plants, fish, or animals
- Presence of a particular syndrome known to be associated with a chemical agent or biological toxin.

The presence of any of these clues, especially when accompanied by a credible threat, should elicit further epidemiological investigation to determine whether an incident has occurred and to define the population at risk. Local and state public health authorities have primary responsibility for the epidemiological response unless the incident occurs on federal property or in a federal facility, in which case the CDC will lead the epidemiological investigation. The CDC would most likely be requested to help support the local/state epidemiological response due to ricin's inherent toxicity, its classification as a Category B bioterrorism agent, and the specialized testing required for such a release.

5.2 Mechanism of Action and Toxicity of Ricin

Ricin exerts its toxicity by inhibiting protein synthesis through ribosomal inactivation. Given a sufficient absorbed dose, this leads first to cellular death, then to tissue damage, and can ultimately result in multi-system organ dysfunction and organism death. Ricin is a protein consisting of an A and B chain. The A chain is the enzyme that inactivates the ribosome, while the B chain binds the toxin to the cell. The toxicity of ricin can vary by its form, dose, purity, and route of absorption, as described on the following page.

- Animal studies suggest that, with inhalational exposure, potency increases as the particle size decreases to about 1 μm.[4] The smaller-sized particles can deposit deeper into the respiratory tract, potentially causing higher mortality.[5]
- Time to onset of ricin poisoning is dose dependent.[6]
- Injection or inhalation of ricin toxin is more likely to cause a quicker onset of poisoning and cause a more rapid progression of illness compared to ingestion, given the same exposure amount.[7]

5.2.1 Toxicity by inhalation and intravenous injection

Studies on mice have shown that inhalation and intravenous injection are the most lethal routes of exposure, with an LD_{50} (i.e., dose required to kill 50% of mice tested) between 3 and 5 μg/kg.[8] The lethal dose for humans by inhalation or injection is estimated to be 5 to 10 μg/kg.[2]

5.2.2 Toxicity by ingestion

The LD_{50} for ingestion of ricin in mice is 20 to 30 mg/kg, or about 1000-fold greater than for inhalation or intravenous injection.[3] This is thought to be due to the large size of the ricin protein, which renders it poorly absorbed orally (as well as through unabraded skin) and degraded by gastrointestinal enzymes.[6]

5.3 Route of Exposure to Ricin

There are three possible routes of exposure[a] to ricin—inhalation, ingestion, or injection. Each is associated with a unique set of clinical manifestations (table 5.1). Regardless of the route of exposure, ricin poisoning is *not* contagious; it cannot spread from person to person through casual contact**.** However, it could be spread from person to person if powder were on the clothing of exposed individuals.

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[a] Ricin exposure is defined as the release of ricin resulting in a person(s) being at risk for developing ricin poisoning.

Table 5.1. Clinical symptoms and progression of disease associated with ricin poisoning, by route of exposure.		
Route of Exposure	**Common Clinical Symptoms**	**Progression of Disease**
Inhalation	▪ Rapid onset of irritation of nose and throat ▪ Respiratory distress possibly leading to respiratory failure ▪ Dyspnea (difficulty breathing) ▪ Pulmonary edema ▪ Flu-like symptoms of fever, weakness, nausea, myalgia (muscle pain), or arthralgias (aches and pains in joints)	▪ Cough, difficulty breathing, flu-like symptoms within 4-8 hrs ▪ Hypotension and pulmonary edema within 18-24 hrs ▪ Death may occur within 36-72 hrs
Ingestion	***Mild:*** ▪ Nausea, vomiting, diarrhea, abdominal cramping and pain ***Moderate to severe:*** ▪ Persistent vomiting and voluminous diarrhea—bloody or non-bloody ▪ Dehydration and hypovolemic shock ▪ Hepatic and renal failure possible ▪ Mild hemolysis (not requiring blood transfusions) ▪ Liver and kidney dysfunction	▪ Rapid onset of nausea, fever, and abdominal cramps within 1-6 hrs ▪ GI symptoms may occur as late as 10 hrs ▪ In mild cases, the symptoms often resolve in 24 hrs ▪ In severe cases, death may occur within 36-72 hrs
Parenteral (injection)	▪ Flu-like symptoms with fatigue and myalgias ▪ Local necrosis of muscles and regional lymph nodes at injection site ▪ Pain at injection site ▪ Weakness, fever, and/or vomiting ▪ Shock ▪ Multi-organ failure	▪ Weakness or pain at site of injection within 5 hrs ▪ Fever & vomiting within 24 hrs ▪ Death may occur within 36-48 hrs
Sources: Centers for Disease Control and Prevention, "Interim Ricin Response Plan (Draft). February 6, 2004; NIOSH Emergency Response Card: Ricin. February 18, 2004. Available at: http://www.bt.cdc.gov/agent/ricin/erc9009-86-3.asp.		

5.4 Case Definition for Ricin Poisoning

Based on the limited data available, significant ricin poisoning via inhalation or ingestion would likely consist of a progressive worsening of symptoms over 4 to 36 hours. Because early clinical symptoms are nonspecific, it initially may be difficult to discern true ricin poisoning from a respiratory infection (if inhalational exposure) or gastroenteritis (if ingestional exposure). Therefore, suspicion of intentional ricin poisoning should occur in conjunction with the epidemiologic clues previously noted, a highly suspected or known exposure, or a credible threat.

The CDC case definitions for ricin poisoning are provided below:[9]

- ***Suspected:*** A case in which a potentially exposed person is being evaluated by healthcare workers or public health officials for poisoning by a particular chemical agent, but no specific credible threat exists.
- ***Probable:*** A clinically compatible case in which a high index of suspicion (credible threat or patient history regarding location and time) exists for ricin exposure, or an epidemiologic link exists between this case and a laboratory-confirmed case.
- ***Confirmed:*** A clinically compatible case in which laboratory tests have confirmed exposure.

A case can be confirmed if laboratory testing was not performed because either a predominant amount of clinical and nonspecific laboratory evidence of a particular chemical was present or a 100% certainty of the etiology of the agent is known.[9]

5.5 Assessment of the Exposure Risk

Factors that determine the population at risk of exposure include the geographic location where the ricin was released, the quantity and purity and characterization of ricin released, and the route and duration of the exposure. The initial epidemiological investigation should include interviews with known or suspected victims (or appropriate surrogate) in an effort to identify geographic points of interest visited within 72 hours prior to the interview.[3] The following are examples of geographical points of interest:

- Primary residence
- Place of employment or school
- Places of worship
- Hotels or convention centers
- Shopping malls
- Postal facilities
- Public transportation (e.g., airplane, train, subway, bus) and transportation hubs
- Medium to large-scale gatherings (e.g., movie theaters, sporting events, concerts, restaurants, parks)

The epidemiological investigation may also benefit from sending a message through the Health Alert Network (HAN) to clinical providers in the area of the suspected incident. Feedback from clinicians can help verify whether an “incident” really has occurred and, if so, help determine its scope and impact on the community. The message should be targeted primarily to hospital emergency departments (EDs) and primary care clinics in the nearby area.

Epidemiologists leading the investigation should obtain contact information for persons who are interviewed, others identified who might have been in the affected area, and names and contact information (if possible) of close contacts of those exposed. This information should be input into a database that can be used to track the health status of all persons that were potentially exposed.

The following general guidance is provided on assessing the population at risk for the different possible routes of exposure. Information is also given on the exposure risk to response personnel and healthcare workers.

5.5.1 Inhalation of ricin (via mail)

Prior experience with ricin has shown that the threat of inhalational exposure might involve the delivery of ricin through the mail, which then becomes aerosolized when the contaminated package or letter is opened. In this particular scenario, the population at risk would include the following:

- The person who opened the contaminated package or letter and those in the immediate vicinity or who perform similar jobs or activities
- People in nearby rooms or areas that share the same ventilation system as the contaminated area
- Postal workers (sorters, letter carriers, etc.) at facilities that handled the contaminated mail
- People who might have come into contact with contaminated items, such as clothing (while the respiratory risk is negligible, these people should still be monitored for signs or symptoms consistent with ricin poisoning).

5.5.2 Ingestion of ricin

If the suspected route of exposure is ingestion, a detailed epidemiological investigation should be conducted to identify all food and beverages consumed 24 hours prior to the onset of illness. If victims can be traced to a common location (e.g., restaurant, grocery store, cafeteria), it’s important to identify and interview all potential patrons who may have consumed similar food or beverage. The population at risk would include:

- People who ate or drank (or purchased food or drink) at the common location within the previous 24 hours
- Workers who may have prepared or handled food or drink during the 24-hour period (as they may have incidentally consumed food or drink)
- People who purchased a specific type of food or beverage (perhaps at various locations) that is suspected of being contaminated.

5.5.3 Injection of ricin

In the case of parenteral exposure, the population at risk is defined as the person(s) directly injected with the ricin. Injection is not therefore considered a viable method for use in a mass casualty incident.

5.6 Surveillance and Reporting

This section examines the importance of using surveillance systems, both as a means to detect a possible covert ricin attack and to respond to an attack once it has been detected. The latter involves surveillance for the various syndromes of ricin intoxication in the exposed population. Notification and reporting procedures are also described to assist public health and medical communities in responding to a ricin incident.

5.6.1 Epidemiological investigation and disease surveillance

Detection of a covert ricin attack will likely occur through the recognition of clusters of patients with similar symptoms and an elevated index of suspicion due to epidemiologic clues (noted in Section 5.1), a highly suspected or known exposure, or a credible threat. Ongoing surveillance may help identify persons exposed to ricin and should include:[3]

- Poison control centers (using the Toxic Exposure Surveillance System)
- Hospitals or other healthcare facilities (e.g., surveillance of intensive care unit, ED, morgue, referral centers, pharmacy, lab)
- Medical examiner or coroner (including deaths of unexplained etiology)
- Emergency services utilization (911 calls)
- Primary care providers (if possible)
- Pharmacy services
- Veterinary clinics.

Cases of known or suspected ricin poisoning should be reported to the local and state health department, the FBI, and the CDC. Working in coordination with local and state health officials and the FBI, the CDC, in coordination with the local and state health department, will conduct a measured response as outlined below.[12]

- Use the toxic syndrome description to determine whether clinical findings are consistent with ricin poisoning.
- Conduct an epidemiological investigation.
- Assess the credibility of the threat or possibility of exposure by consulting the FBI and local law enforcement agencies.

The local health department, the FBI, and the CDC will evaluate information obtained from the legal and epidemiological investigations to decide whether environmental testing is likely to aid in the confirmation of ricin poisoning. If necessary, the CDC can deploy a team of epidemiologists, medical toxicologists, and industrial hygienists to conduct an environmental assessment and public health investigation. Environmental samples would be obtained as per CDC and FBI protocols, tested for ricin and any possible metabolite or degradation product, and maintained using proper chain of custody procedures.

Persons identified as exposed, or at risk of exposure, but who are asymptomatic, should be closely monitored for the development of illness or symptoms consistent with ricin poisoning. A thorough medical history of these people should be taken, and they should be closely monitored during the first 24 hours because clinical effects may vary significantly within the exposed population. Consideration may be given to admitting high-risk exposures in hospitals for observation. If no symptoms develop within 24 hours, the person may be discharged home, but cautioned to seek medical care immediately if symptoms appear.

Long-term surveillance should consist of the following:[3]

- Follow potentially exposed cohorts for 1-2 months after initial diagnosis to detect sub-acute syndromes and also to be alert for new or re-exposure due to inadequate decontamination of site.
  - Monitor absenteeism and hospitalization
  - Monitor occupational health clinic for suspicious illness
- Monitor intensive care units and emergency rooms for severe respiratory disease or gastrointestinal illness
- Monitor LRN reports of positive ricin/ricinine tests
- Monitor medical examiners and coroners for unexplained deaths.

5.6.2 Case reporting

The following cases should be reported to local and state health agencies, as well as to regional poison control centers (1-800-222-1222).[13] These centers, in turn, should notify the CDC Emergency Operations Center (770-488-7100).

- Suspected or known cases of ricin exposure
- Any cases of ricin-associated illness
- Clinical illness consistent with ricin poisoning in conjunction with a credible threat
- Clinical illness consistent with ricin poisoning in conjunction with an applicable epidemiologic clue.

Mechanisms (e.g., telephone, e-mail) for reporting suspected, probable, and confirmed ricin exposures to public health officials should be established and communicated to hospitals, clinics, private practice physicians, and other potential reporting sources. This may be accomplished using the HAN as well as other media, since not everyone is connected to the HAN or checks it regularly.

The "Interim Recommended Notification Procedures for Local and State Public Health Leaders in the Event of a Bioterrorist Incident" can be accessed via the Internet at: http://www.bt.cdc.gov/EmContact/Protocols.asp.

5.7 Forensic Epidemiology

The potential criminal use of ricin as a terrorist weapon underscores the need for public health and law enforcement agencies to understand the goals and methods that each uses in its investigations.[14] Information or data from epidemiological investigations may have evidentiary implications in follow-on criminal proceedings. The intersection of the public health and law enforcement response is known as *forensic epidemiology*, which the CDC has defined as:

> *"The use of epidemiologic methods as part of an ongoing investigation of a health problem for which there is suspicion or evidence regarding possible intentional acts or criminal behavior as factors contributing to the health problem."*[15]

The CDC, in partnership with other Federal and State agencies (including the FBI), has developed a forensic epidemiology course designed for the joint training of public health and law enforcement officials. The course objectives address three key areas: (1) criminal and epidemiological investigative methods; (2) operations and procedures; and (3) communications.[b]

Increased interactions between public health and law enforcement personnel have raised a host of legal issues related to:

- Gathering admissible evidence during public health investigations
- Access to premises (i.e., law of entry)
- Establishing and maintaining chain of custody of evidence
- Disclosing confidential health information by public health to law enforcement
- Restricting a person's freedom of movement after exposure to a communicable disease.

Because incidents (isolated or large-scale) involving known or suspected ricin poisoning likely result from criminal activity, it is important that public health investigations conform to legal standards. Among other things, this includes the Fourth Amendment prohibition against unreasonable searches and seizures, and the Fifth Amendment protection against self-incrimination. Therefore, public health investigations should be coordinated closely with law enforcement officials and any ongoing criminal investigations. One way this can be accomplished is the use of interdisciplinary investigative teams. Such teams ensure a common understanding of what is important to the other agency's investigation and help provide the best chance for successful prosecution.

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[b] Additional information on the forensic epidemiology course can be accessed at: http://www.phppo.cdc.gov/od/phlp/ForensicEpi/ForensicEpi.asp.

To be admissible in a criminal prosecution, evidence gathered in an investigation must be properly maintained and accounted for from the time it is discovered until presentation in the courtroom. This requires establishing a *chain of custody*. Any person taking custody of possible evidence should make an entry into a chain of custody form, which identifies and documents:

- *Every* person who handled the evidence
- How evidence was transferred from one person to another
- Procedures used to safeguard evidence from tampering
- Procedures used to transfer or dispose of evidence after it was examined.

Some States have passed legislation providing an exception to confidentiality laws, thus allowing the sharing of otherwise confidential medical information with law enforcement officials regarding persons who have or may have a communicable disease. Responders and investigative personnel should consult their legal authority for the applicable laws in their State.

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6.0 Medical Treatment

This chapter describes available medical countermeasures for ricin poisoning based on the route of absorption. It also examines the short- and long-term mental health implications for first responders, the emergency medical community, victims, and the general public, and provides information for accessing appropriate resources. Some key points of this chapter include the following:

- Skin decontamination of victims exposed to ricin in powder form should occur before transport to the hospital (if possible) and includes removing all suspected contaminated clothing and jewelry and washing with copious amounts of soap and water.
- Initial clinical symptoms of ricin poisoning are non-specific and may be hard to distinguish from a respiratory infection (inhalational exposure) or gastroenteritis (ingestional exposure). The differential diagnosis should include agents that are associated with respiratory and gastrointestinal illnesses.
- While there is no antitoxin or approved vaccine for ricin poisoning, supportive therapy is available and most beneficial if delivered quickly after exposure and subsequent onset of poisoning.
- Mental health issues during a ricin incident may be significant. First responders, victims, family/friends, and the general public should be given information and directed to appropriate resources to address their mental health needs.

6.1 Definition of ricin as a dangerous agent

Ricin is listed as both a biological and chemical agent on the CDC Web site,[3] and ricin is classified as a Category B priority pathogen under the National Institute of Allergy and Infectious Disease strategic plan.[4] As defined by the CDC, Category B agents are moderately easy to disseminate, can result in moderate morbidity rates and low mortality rates, and require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance.[5] Legally, possession of ricin is covered by the "Biological Weapons Anti-Terrorism Act of 1989" (Title 18 US Code Sections 175-178) and the "Chemical Weapons Convention Implementation Act of 1998" (18 USC 229). Ricin is a “Select Agent” as defined by 42 CFR 72 & 73.

6.2 Toxicity of ricin

A comparatively large amount of ricin would be needed to produce an effective large-scale weapon of mass destruction. A common way to discuss the lethality of an agent is to describe it in terms of its Lethal Dose, 50% (LD_{50}). The LD_{50} is the amount of substance that, when administered by a defined route of entry (i.e., ingestion, inhalation, injection) over a specified period of time, is expected to cause the death of 50 percent of an exposed population. Another term LCt_{50} (C = concentration to which an organism is exposed, t = time during which an organism is exposed to that concentration) is used to denote the vapor or aerosol exposure necessary to cause death in 50 percent of the population exposed.[6]

Data is not available on aerosol toxicity exposure to ricin for humans, and is approximated by analogy with the toxicity levels to ricin displayed in certain experimental animal models (e.g., mice, primates). The lethal inhalational dose for humans is estimated to be 3 μg/kg.[7] Considering a 70 kg (175 lb) person, the LD_{50} by an inhalational route is 0.280 mg, and the LD_{50} by an intragastric route is 1,400 mg. Ricin toxin and botulinum toxin are commonly grouped as some of the most likely biotoxins that might be produced for terrorist purposes, but their toxicities are not equivalent. To compare the lethality of ricin to that of botulinum toxin, the LD_{50} of botulinum toxin is 0.001 μg/kg, or three orders of magnitude smaller than ricin; therefore a greater amount (1000 times) of ricin would be needed to produce the same effect as a specified amount of botulinum toxin.

Ricin is most likely to be a threat as a water and food contaminant or in a small-scale contact attack. To disperse efficiently, ricin would need to be prepared in homogenous particles that are less than 5 microns in size, in order to enter the lungs. Preparation of such a dispersible mixture and the subsequent dissemination of this mixture are not trivial matters. However, the starting material (castor beans) for preparing ricin is cheap and plentiful, and someone with a reasonable amount of laboratory experience can perform the actual preparation of ricin; these two factors make ricin an attractive candidate for potential malefactors.

6.3 Victim Decontamination

If ricin is disseminated in powder form, immediate skin decontamination is advised due to the risk of re-aerosolization of agent, inadvertent ingestion, or mucous membrane contamination. Persons suspected of being contaminated with ricin should receive gross decontamination prior to their arrival in a healthcare setting (e.g., hospital). Generally, decontamination at the scene of the release or exposure is preferable, unless the patient's medical condition dictates immediate transport to the hospital. Gross decontamination includes the following steps:[1]

- Cut away or otherwise remove all suspected contaminated clothing (do not pull clothing over the head), including jewelry and watches. These items should be double-bagged and labeled as contaminated, and secured in a safe location until they can be properly turned over to law enforcement as evidence.
- Wash off obvious contamination with soap and copious amounts of water.
- Shower with liquid soap and warm water.
- There is no need to perform skin decontamination for patients exposed to ricin through ingestion only.

For the comfort of the victims and to improve cooperation, the water should be at a comfortable temperature (if possible) and attention should be given to privacy considerations and to the security of personal belongings. The procedure should be explained thoroughly to the victim so he/she understands what is occurring. Control of contaminated wastewater will be addressed in Chapter 8.

6.4 Differential Diagnosis

The basic signs and symptoms that CDC gives for the case definition for inhalational ricin exposure are cough and respiratory distress followed by pulmonary edema, respiratory failure, and multi-system organ dysfunction. Weakness and influenza-like symptoms of fever, myalgia, and arthralgia might also be reported. The initial clinical symptoms of ricin poisoning are non-specific and may be difficult to distinguish from a respiratory infection (if inhalational exposure) or a common gastroenteritis (if ingestional exposure).[a]

With aerosolized ricin, the differential diagnosis can include, but is not limited to, influenza, Q fever, tularemia, plague, anthrax, illness due to staphylococcal enterotoxin B (SEB), Severe Acute Respiratory Syndrome, paraquat, irritant gases, particulate matter, polymer and metal fume. In addition, illness due to chemical agents such as phosgene should be considered.[2] Ricin-induced pulmonary edema would be expected to occur later than if induced by SEB (about 3-12 hours post-exposure) or phosgene (12-24 hours post-

[a] See Chapter 5, table 5.1, for a list of the common clinical symptoms associated with ricin poisoning.

exposure).[2] Nerve agent intoxication would be characterized by acute onset of cholinergic crisis with dyspnea and profuse secretions. Ricin does not cause mediastinitis as seen with inhalational anthrax.

Additional supportive radiographic or laboratory features after aerosol exposure to ricin include the following:[2]

- Bilateral infiltrates on chest radiographs
- Arterial hypoxemia
- Neutrophilic leukocytosis
- Bronchial aspirate rich in protein compared to plasma that is characteristic of high-permeability pulmonary edema.

The differential diagnosis in cases of suspected ricin ingestion should include disease due to all of the major enteric pathogens. *Salmonella* or *Shigella,* certain mushrooms, caustics, metals, arsenic, shellfish poisoning, *Staph aureus* enterotoxin, *Bacillius cereus*, *Clostridium perfringens*, and colchicine should be considered. Many may be able to be ruled out by history and appropriate laboratory testing.

6.5 Ricin Countermeasures

Any confirmed or suspected cases of ricin exposure should be reported immediately to the regional poison control center. The American Association of Poison Control Centers has a nationwide number (1-800-222-1222) for access to the 62 U.S. poison control centers. The number is routed to the local poison center serving the caller, based on the area code and exchange of the caller. The number is functional 24 hours a day in the 50 States, the District of Columbia, the U.S. Virgin Islands, and Puerto Rico.

There is no effective antidote for ricin poisoning; however, supportive medical care can be given to help minimize the effects of the poisoning. The type(s) of supportive care is dependent on several factors, such as the route of exposure. Care could include such measures as helping victims breathe, replenishing fluids, giving medications to treat hypotension (low blood pressure) and seizure, and other methods to limit the amount of ricin in the body.[3] The level of supportive care is related to the degree of cellular disruption, and prolonged intensive care and complex medical management may be required. As ricin toxin inhibits protein synthesis in a patient’s cells, clinical signs and symptoms of ricin poisoning will slowly evolve (see Table 5.1 for possible timeframe of progression of disease. Note that these data were derived from measuring inhalational toxicity in a non-human primate study. Humans can be expected to follow the same course of illness.)

6.5.1 Treatment of inhalational poisoning

General treatment of acute pneumonia and interstitial pulmonary edema includes supplemental oxygen, pulmonary toilet, respiratory therapy, and mechanical ventilation with positive end expiratory pressure to maintain oxygenation. Intravenous (IV) fluids, vasopressors, and metabolic and nutritional support also may be required. Intensive care is required in all severe cases. Milder cases may improve spontaneously, but due to the uncertainty of prognosis, close monitoring of patients is imperative.

6.5.2 Treatment of gastrointestinal poisoning

Experience involving castor bean mastication has shown that severe ricin poisoning by ingestion is less likely because ricin is not well absorbed into the gastrointestinal tract. Even with little or no effective supportive care, the mortality rate in symptomatic patients is low—about six percent.[4] However, serious and even fatal ingestions of castor beans have been reported, thus it is possible with a sufficient dose for gastrointestinal poisonings to occur.

Treatment options are available for people who have symptoms consistent with oral intoxication. While there is no scientific evidence for or against the various techniques, the same general guidelines used for other toxins should be applied for ricin.

- A single dose of activated charcoal should be given as soon as possible if the patient is suspected of ricin ingestion and is not vomiting.[5]
- Gastric lavage should be considered if the victim presents to the hospital within one hour of ingestion, is not vomiting, and there are no contraindications to the procedure.[5]
- IV fluid administration and vasopressors may be necessary to counter fluid loss and hypotension.
- Whole bowel irrigation, cathartics, and syrup of ipecac are *unlikely* to be beneficial in ricin ingestion.[5]

6.5.3 Vaccine development

Currently, there is no approved pre-exposure or post-exposure prophylaxis to prevent ricin poisoning. There is ongoing research on potential vaccine candidates, which are briefly described below.

Researchers at the University of Texas Southwestern Medical Center have employed recombinant DNA technologies to develop RiVax™, a genetically modified protein in which the portion of the ricin A-chain that inhibits protein synthesis has been deleted.[6] The protein induces antibody production in mice when delivered intramuscularly.[7] As of February 2006, RiVax™ has been shown to be safe and capable of eliciting ricin-neutralizing antibodies in first phase human trials.[8] In addition, a nasal formulation is being developed for ease of administration to large numbers of people, and to improve mucosal protection to the respiratory tract—the source of entry for an inhalational exposure.[9]

Scientists at USAMRIID have conducted studies on a new vaccine called RTA 1-33/44-198. This candidate is a fragment of the ricin A-chain (RTA) that has been modified to eliminate the toxic enzymatic property of the A-chain, increase protein stability, and maintain its ability to elicit a protective immune response.[10] When tested in mice exposed to whole-body aerosol challenge with lethal doses of ricin, the results have been promising. Further work is continuing on this candidate vaccine.

6.6 Long-Term Medical Care

In the absence of an effective antidote, people who develop symptoms of severe ricin poisoning may require long-term (i.e., greater than six months) treatment. There is not much information known regarding long-term injury due to ricin poisoning. Long-term care for inhalational ricin exposure may include the following:

- Ventilatory assistance may be required for patients who inhale aerosolized ricin and survive the initial necrotizing pneumonitis. This requires intensive care and ventilator support until the pulmonary tissue can heal (may be weeks or months). The extent of illness and survival rates will determine long-term care capacity. Once discharged, the patients may require ongoing oxygen therapy or rehabilitation. Some may be permanently disabled.
- Some patients may require hemodialysis for renal failure, either temporarily or permanently. As discussed elsewhere, nephritis may be directly caused by ricin ingestion. It also may result from metabolic imbalances associated with severe illness, such as pulmonary failure. The dialysis may be temporary if renal tissue heals, or permanent if it does not. If permanent, these patients will require renal transplantation for ultimate recovery.

6.7 Mental Health Considerations

A unique characteristic of bioterrorism, compared to many other forms of disaster, is that its victims often do not witness a defined event with tangible elements of impact.[11] This can lead to unique mental health issues for people directly affected by a bioterrorism event, their family and friends, emergency response personnel and healthcare workers, and the general public. For example, victims may be more prone to feelings of alienation, abandonment, and stigmatization in events with no visual impact, as there may be less a sense of shared experience within the greater community.[11] In the case of ricin, victims do not pose a contagious risk but may be treated like they do, thus leading to feelings of isolation among those affected.

Although often overlooked, mental or behavioral health issues make up a key aspect of disaster response. Psychological reactions can greatly impact the response system by increasing workload for healthcare facilities that already may be stressed, imposing an additional diagnostic burden on clinicians, and hindering cooperation with preventive efforts or public health messages.[11] Not to be forgotten are the mental health needs of first responders, emergency medical personnel, and others whose occupation may be directly affected by a disaster.

6.7.1 Short- and long-term psychological effects

Ricin poisoning may cause both short- and long-term psychological effects. In the short-term or immediate phase, people are likely to feel tremendous fear, confusion, panic, and anxiety about threats to their personal health and safety and that of loved ones. Longer-term mental health issues include depression, post-traumatic stress disorder (PTSD), anxiety, and substance abuse. Interventions should be designed to address both the short- and long-term mental health consequences of the ricin incident.

6.7.2 Resources for addressing mental health issues

Beyond their physical care requirements, victims of an intentional ricin attack should be assessed for their mental health needs. This may also be necessary for the loved ones of those directly affected, their coworkers or friends, as well as response personnel. The CDC has developed a mental health survey instrument (adapted from several tools) to provide State or local health departments and other decision-makers with useful data for investigating the psychological symptoms associated with a mass trauma event. The survey may be administered by phone, or face-to-face interview, or given as a pencil-to-paper assessment. The data can then be provided to decision-makers to guide the public health response or to provide the basis for more in-depth investigations. The survey is available on CDC's Web site at: http://www.bt.cdc.gov/masstrauma/mhsurvey.asp.

The Substance Abuse and Mental Health Services Administration (SAMHSA) also has established a Disaster Technical Assistance Center (DTAC) to help States, Territories, and local entities deliver an effective behavioral health response during disasters. The DTAC provides technical assistance to States, Territories, and jurisdictions throughout disaster response and recovery and may help in identifying the following:

- Suitable publications
- Psychoeducational materials
- Expert consultants.

In addition, DTAC staff maintains a contact database of State and Territory mental health commissioners, substance abuse directors, and disaster coordinators, as well as a roster of Federal agencies and non-government organizations (NGOs) involved in disaster and trauma research and/or service delivery. This database might prove helpful in identifying mental health practitioners near the area of the ricin attack to assist with mental health needs. The DTAC maintains:

- Toll-free help line (1-800-308-3515)
- Comprehensive Web site (http://www.mentalhealth.samhsa.gov/dtac/default.asp)
- E-mail address (dtac@esi-dc.com).

It is important to not forget about or underestimate the impact that a disaster can have on first responders and emergency medical personnel. Self-monitoring and peer monitoring are critical to identifying stress or mental health issues among responders. The following steps can help minimize stress-related or mental health issues.[12]

- Encourage response personnel and healthcare workers to monitor themselves and each other with regard to basic needs such as food, drink, and sleep.
- Ensure regular breaks from disaster response and recovery operations, or from direct patient care activities.
- Establish a place for responders and healthcare workers to talk to their colleagues and receive support from one another.
- Remember that not all people respond the same to a disaster or stressful situation. Some may need to talk about their feelings, while others may need to be alone. Recognize and respect these differences.

Debriefing, which is a commonly used (although debated) tactic of emergency response personnel following a trauma, may be helpful in mitigating the effects of severe trauma and can identify individuals who need further assistance. Bringing people together by an active outreach approach (through schools, community centers, disaster shelters, etc) is essential since many of the affected individuals will hesitate to actively ask for help.

Additional agencies and organizations that might prove useful in providing resources or support in the identification and treatment of mental health needs include:

- **American Red Cross** (http://www.redcross.org/services/disaster)
- **Anxiety Disorders Association of America** (http://www.adaa.org/index/cfm)
- **National Center for Posttraumatic Stress Disorder** (http://www.ncptsd.org)
- **National Institute on Mental Health** (http://www.nimh.nih.gov)
- **PHS Commissioned Corps Mental Health Teams** (http://www.usphs.gov/)
- **Posttraumatic Stress Disorder Alliance** (http://www.ptsdalliance.org).

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7.0 Public Information and Risk Communication

During a crisis, the public looks to elected officials, community leaders, and public safety and emergency response personnel for assurance that actions are being taken to alleviate the effects of the disaster and for recommendations on steps the public can take to ensure their safety.[1] This chapter describes general processes to coordinate public information across multiple jurisdictions and response agencies. It provides examples of messages that might be developed and implemented specifically for a ricin event and includes risk communication resources that could be useful during a response. Major points contained in this chapter are:

- Information regarding the event should be coordinated across response agencies and jurisdictions to speak with a unified voice and present a consistent message to the public.
- Risk communication messages should have appropriate input from subject matter experts. The messages should explain the nature of the agent/contaminant (where ricin is found, the fact that ricin poisoning is not contagious) and discuss the health risks associated with ricin exposure (e.g., signs and symptoms, what to do if you are exposed to ricin, treatment for ricin poisoning).
- Implementation of the risk communication strategy must take into account several factors such as acknowledging sympathy and concern towards victims and families, putting out information on a regular basis, and presenting clear, concise, and technically correct messages.

7.1 Coordination of Public Information

State, local, and tribal authorities have primary responsibility for providing information to their citizens. During a known or suspected ricin incident, Federal agencies also will be involved in the response because of ricin's status as a potential weapon of choice for terrorists. The various government entities and response agencies must coordinate closely so that they speak with a unified voice and present a consistent message. Inconsistent messages to the public increase anxiety, decrease the likelihood the public will abide by the communicator's recommendation, and diminishes the communicator's credibility.[2]

To facilitate multijurisdictional and multiagency coordination, the Incident Commander (IC) should establish a Joint Information Center (JIC). The JIC is a collocated group (*note: the JIC may be virtually rather than physically collocated*)[a] of representatives from agencies and organizations involved in an event that handles public information needs.[2] Its structure is flexible and designed to expand to accommodate local, State, and Federal personnel based on the needs of the incident. This helps to ensure that press secretaries from various government and response entities have access to the same information and risk communication messages.

The Public Affairs Support Annex to the NRP and Emergency Support Function (ESF) #15 – External Affairs Annex – provides more information on the role and operation of the JIC. In addition, the National Response Team (NRT) has developed a JIC manual, available at: http://www.nrt.org.

Finally, DHS Public Affairs operates and maintains a standing conference line known as the National Incident Communications Conference Line (NICCL). The NICCL serves as the primary means for interagency incident information sharing during an Incident of National Significance and helps facilitate interagency coordination.[3] DHS Public Affairs provides guidance to Federal interagency public affairs staffs through NICCL.

7.2 Developing the Risk Communication Strategy

A communications strategy for a ricin response should answer the key questions below, and should be consistent with the lead agency's risk communication plan.[b] To ensure that accurate and timely information is provided to those involved or affected by the incident, these questions should be answered and the strategy outlined before any communications or outreach activity is implemented.[4]

[a] A virtual JIC links all participants through technological means when geographical restrictions, incident management requirements, and other limitations preclude physical attendance by public affairs leadership at a central location.

[b] Plans should be developed prior to any incident. Information for help in creating a plan and preparing risk communicators can be found at http://www.cepis.ops-oms.org/tutorial6/i/index.html

- What specific areas and populations are impacted by the contamination, or are at risk of being impacted? What areas and populations are not directly impacted?
- How will responders communicate with the community, local officials, and the media? Who will be responsible for each of those lines of communication?
- Which organizations are involved in the response? What is their specific role?
- What are the key messages the response team and/or other key agencies will need to convey to the public? Who will convey them, by what mechanism? Who will set the briefing schedule, and when/where will briefings occur?
- What other key public perception or risk communications issues need to be addressed, and which agencies/representatives are responsible for providing information and making decisions?

As part of strategy development, it is important to set communications goals and identify support messages before issuing any public comments. Goals and messages should be simple, straightforward, and realistic.[4] These are important in establishing trust with the audience. It is also critical to assess the environment into which information is being introduced.[5] A sense of the public's general attitude toward the situation should be understood, and the presentation tailored accordingly.

7.3 Developing Risk Communication Messages

Subject matter experts (SMEs) should have input into the development and/or review of risk communication messages to ensure their accuracy. Ideally, the SMEs should be comfortable dealing with the media. The CDC and National Institutes of Health have developed a list of SMEs that they can rely on to do television interviews. This list should be consulted during a ricin incident to identify an appropriate SME to aid in developing and delivering public messages.

The duties of the Surgeon General include articulating scientifically-based health policy analysis and advice to the President and the HHS Secretary on the full range of critical public health, medical, and health system issues facing the Nation, of which a ricin incident would be one example (http://www.surgeongeneral.gov/).

7.3.1 Key messages for a ricin incident

Public perception about the health risks associated with ricin can vary widely depending on what information is received. The CDC has developed a "questions and answers" information sheet for ricin that can be referenced in developing the initial public health message (http://www.bt.cdc.gov/agent/ricin/qa.asp). Another key source of information about ricin is a CDC fact sheet (http://www.bt.cdc.gov/agent/ricin/facts.asp), which addresses the following key issues:

- What ricin is
- Where ricin is found and how is it used
- How you could be exposed to ricin
- How ricin works
- Signs and symptoms of ricin exposure
- How ricin poisoning is treated
- How you can protect yourself and what to do if you are exposed to ricin
- How you can get more information about ricin.

In addition, HHS has developed a reference guide for media with information on how the Federal Government will prepare for and respond to acts of terrorism or public health emergencies. The guide addresses what is currently known about ricin, where it comes from, how it can be disseminated, symptoms associated with ricin poisoning, and information on prevention, diagnosis, and treatment. The guide is a valuable resource for developing public messages consistent with the best-known scientific data on ricin. It is available at: http://www.hhs.gov/emergency.

7.3.2 Key messages for public health incidents

Examples of key messages that typically need to be addressed in any health emergency are provided below.[4] The communication strategy should identify a specific communication mechanism, including the lead organization and person responsible, to ensure that questions are answered in an effective and timely way.

- What are the medical and health recommendations for affected or potentially affected persons?
  - Who has made those decisions or recommendations, and with whom have they consulted?
  - Are there associated risks or uncertainties associated with the recommendations?
- What is the status of sampling and/or decontamination procedures?
  - Are results available? If not, when are they expected?
  - If results are available, are they preliminary or are they considered complete and final?
  - Who is in charge of decontamination, and how far along is the process?
- Who decides whether results are final or whether further sampling is necessary?
  - How do they make that decision?
- Are there any remaining limitations or uncertainties associated with the methods or results?

7.5 Implementing the Risk Communication Strategy

Risk communication is based on the concept that "perception is reality." Perceived risks must be taken seriously, and risk communicators should be sympathetic, honest, and accessible to the media and the general public. The first step in implementing a risk communication strategy is to establish a schedule for regular updates of both the public and the media. Once the schedule is established and the media know when and where to receive updates, the following tips will help those delivering the message to do so more effectively:[4]

- **Acknowledge concern and sympathy** for victims and their families before getting into technical discussions.
- **Understand the frustration and stress** they will have and the lack of control they will feel. Be aware that fear of the unknown, lack of information, and the perception that information is being withheld, will increase stress and possibly lead to rumors and mistrust.
- **Anticipate what information people need and in what form** – don't just pass along all the information you have in the format in which you receive it. It is important to know the audience because different audiences (e.g., employees, reporters, local politicians) may need different types of information.
- **Tailor messages to address the specific issues of interest to an audience**, and use an appropriate level of detail and technical information.
- **Use language your audience will understand**. Avoid jargon and terms that may be confusing to the public. For example, to scientists, contaminant levels well below standards are considered to be safe; to the general public, the term "below standards" means low quality or unacceptable.
- **Ensure that messages are technically accurate**. All public information should be reviewed by the appropriate lead agency for its accuracy. Designating lead agency representatives for specific technical issues helps ensure consistency of communications.
- **Provide complete and timely answers to questions and requests for information.** Always acknowledge if the answer is unknown or incomplete, and provide an explanation along with the anticipated time lines for receiving this information. Employers under OSHA jurisdiction are required to make sampling results accessible to their employees. All sampling results must be provided in accordance with 29 CFR 1910.1020, Access to Exposure and Medical Records Regulation, and shared and explained to response workers, as well as to workers returning to the facility after cleanup.
- **Acknowledge answers that are preliminary or may change as a result of ongoing work.** During a ricin incident, there will likely be extensive procedures

and different phases of sampling and decontamination. Depending on the type of sampling and analyses, various procedures may be necessary to confirm or validate sampling results. There are also limitations to both qualitative and quantitative results, including the possibility of false positives or false negatives, or estimation errors in quantified results. All sampling results or other data should include an explanation of how to interpret the information and the limitations of the methods used to generate it.

- **Respond to people's concerns about their personal risk.** Put the data in perspective, and try to express risk in different ways. However, use comparisons that put risks in perspective with caution. For example, comparing a voluntary health risk (e.g., smoking) to an involuntary health risk (e.g., from a hazardous substance in the workplace) can anger those affected by the involuntary risks.
- **Identify appropriate and credible persons to communicate messages** and address concerns. It may be helpful for the JIC to enlist local individuals to serve as spokespersons for various issues. For example, a local elected official may have more credibility within a community than someone at a State or Federal level. In cases involving workers, a union representative may help relay critical information. A local medical person may be useful in communicating risk about public health concerns. Although individual spokespersons may be helpful in communicating particular risks, it is critical that the Unified Command relays uniform, clear, and consistent information through the JIC.

7.6 Monitoring the Risk Communication Strategy

Once a strategy has been developed and the plan implemented, a mechanism is needed to ensure that information is transmitted appropriately to all affected parties. Internal and external communications should be monitored for consistency, timeliness, and accuracy and to identify new issues or perceptions that must be addressed. Below are suggested activities to aid in monitoring the communications strategy:[4]

- Attend all multi-agency meetings. Agencies in small towns may need help and advice. Be prepared for agencies with sensitive issues, unique agendas, and specific constraints.
- Clear any information with the organizations that may be impacted by the public response before advising the public. For example, check with local hospitals and health officials before advising the community to seek care at the hospital ED.
- Ensure that information is reaching diverse populations identified within the impacted area.
- Continue to monitor media coverage of the event and develop a checklist for things to be included in the public outreach message that will be generated by the JIC. Correct any misinformation promptly.

- Check that all those in sight during reports from the scene are following the safety rules and wearing appropriate safety gear. Discrepancies between what is being reported and what is being seen will lead to mistrust of the information.
- Clear any appeal for public assistance. Sometimes the response to such appeals is overwhelming to the point that personnel have to be diverted from their emergency response roles to process volunteer or donated assistance.
- Collate and archive common questions and answers from the incident that can be used to respond to future incidents.
- Develop and maintain good records documenting advice received from public health officials and others about the communication of health-related information to workers and the general public.
- Reevaluate measures that have already been taken to determine whether they should continue. If differences are observed in response actions or the public message, make sure the reasons for these differences are understood and communicated clearly to the public.

7.7 Resources Available for Risk Communication Personnel

The CDC has an emergency communications team made up of expert communicators who translate scientists' findings and recommendations to the media, laboratories, clinicians, State and local health departments, academia, and national and international corporations.[5] In addition, a public response hotline is available through the CDC to disseminate resources and information to the public in English (888-246-2675) and Spanish (888-246-2857). Materials may also be accessed via the Internet at: http://www.bt.cdc.gov.

To aid organizations in developing and disseminating emergency risk communication messages to the public, the CDC has created a detailed Web site that can be accessed at: http://www.cdc.gov/communication/emergency/erc_overview.htm. The CDC has also developed a training manual by leaders for leaders on emergency risk communication. The manual is available at: http://www.cdc.gov/communication/emergency/leaders.pdf.

Special teams are available to assist Federal agencies in emergency communications, community involvement, and outreach.

- **The Superfund Emergency Communications and Outreach Team (ECOT)** supports EPA regional emergency responses, specifically during national disasters and other significant events that require public outreach for extended periods of time. ECOT is a resource for building trust and credibility in the community. Its members are experienced Superfund community involvement and public affairs specialists. They allow on-scene coordinators (OSCs) to stay focused on the response by assisting with communications issues. ECOT members can travel to the incident and support or lead communication efforts on-scene, or they can consult by phone or e-mail to suggest strategies for effective community interaction. This team is mobilized as need arises.

- **The U.S. Coast Guard Public Information Assist Team (PIAT)** consists of four emergency communications professionals who are available to Federal OSCs during incidents receiving high media or public attention. Their primary function is to support emergency communications during accidental or premeditated releases of oil or hazardous materials. This specialized team is also deployed to airplane crashes, floods, hurricanes, and incidents involving weapons of mass destruction. The number for the PIAT is (252) 331-6000.

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8.0 Decontamination, Clean-up, and Waste Disposal

This chapter provides information on decontaminating buildings or specific areas, systems, or items within buildings after an actual event of ricin exposure. It also discusses the management of wastes from ricin-contaminated sites.

The ricin molecule is a toxin, which acts by inhibiting protein synthesis in individual cells and results in cell death. Ricin has historically been prepared in an aerosolizable form, which involves generating particles of a uniform size with excellent resuspension properties. However, in most instances in which ricin has been detected, it has been in a much cruder form that is typically oily and poorly aerosolized. Although crude preparations are easier to contain and less likely to result in inhalation, they are still highly toxic if ingested or inhaled. Ricin does not penetrate the skin well, and, although skin contact is to be avoided, it does not present a great risk for dermal penetration of intact skin.

The major steps associated with decontamination and remediation include the following:

- Establish environmental clearance committee and set clearance goals
- Develop a Remediation Action Plan (RAP)
- Site preparation and source reduction
- Selection of methods and verified technologies employed in decontamination
- Waste disposal management
- Clearance sampling and analysis to determine success of remediation
- Clearance decision

Each step is discussed in detail in this section. The following table provides a summary of exposure levels and associated human health risk factors, decontamination methods, and special considerations during decontamination.

1. Decontamination Methods[1]	
Sodium hypochlorite solutions	0.5% sodium hypochlorite solution prepared from household bleach, with its pH lowered into the 6-8 range by adding distilled white vinegar
Thermal inactivation	Treat for 24 hours at 80% relative humidity and 200 °F (93 °C)
2. Special considerations[1]	
Aerosolization	Depends on particle size and purity—collect a characterization sample from the original powder if possible, examine dry filter units if present, wipe sample air duct system
Remediation of mail room	For areas with heavy contamination, use 0.5% solution. For areas adjacent to these, use 0.125% solution (this is enough to detoxify ricin, but for precaution, use the stronger solution when needed). Spray hard surfaces in place and include floors (with attention to baseboards and molding), walls, and horizontal surfaces of furniture and equipment. A 30-minute contact time is recommended. Remove smaller items, and wipe down with the same solution. Resample a percentage of treated surfaces. Soft surfaces could be treated in several ways: (1) treat with decon solutions and then remove (e.g., carpeting cut up and double-bagged) or (2) decon with steam vacuums using an alkali solution (1 N Sodium Hydroxide) as a trap.
Critical items handling	For items from areas outside the prime area with hard non-porous surfaces of concern, wipe with a sponge wetted with 0.1% sodium hypochlorite solution (1:5 dilution of the standard 0.5% decon solution). The first wiping should be done in one direction, then the item should be wiped in a direction oriented 90 degrees from the original direction. The second wipe should not be conducted without rinsing the sponge. The item should then be wiped dry and returned to the owner. For items from the area of prime concern, the item should be wipe sampled, decontaminated if positive, and resampled.
Cross-contamination	Change gloves routinely and remember to change out booties upon entering/exiting specific work areas. Decontaminate buckets containing equipment by wiping the bottoms with decon solution prior to leaving a discrete area, and ensure that buckets are thoroughly decontaminated when exiting the exclusion zone.
3. Remediation Checklist	
❑ Establish environmental clearance committee and set clearance goals	❑ Decontamination
❑ Develop Remediation Action Plan (RAP)	❑ Waste disposal
❑ Site preparation and source reduction	❑ Clearance sampling and analysis
	❑ Clearance decision

8.1 Decontamination and Cleanup (of buildings and items)

Decisions regarding decontamination strategies should be made on a case-by-case basis, considering the specifics of the threat. The selection of a decontamination strategy should be made in consultation with environmental and public health officials from all levels of government, including city, State and Federal agencies, as well as with the advice and recommendations of scientists, manufacturers, engineers, architects, residents, and others as needed. Law enforcement officials also need to be consulted before decontamination begins, allowing for one final opportunity to determine whether additional evidence may exist at the crime scene before it is destroyed by the decontamination of the site.

The objectives of decontamination are the following:

- Eliminate any human health risk due to a potential exposure to residual ricin
- Clean the contaminated area and materials with a minimum of damage as quickly as possible, safely, and in an environmentally friendly manner.

Decontamination and cleanup activities follow first response and site characterization activities. Information gained during site characterization informs the remediation process and includes the following:[2]

- Screening sampling and analysis to determine the identity and approximate locations of contamination by ricin
- Characterization of the ricin
- Characterization of the affected site
- Estimation of exposure and risks
- Containment to prevent the spread of ricin
- Development of a characterization environmental sampling and analysis plan.

The nature of the contamination includes the physical properties of the ricin containing material discovered at the site. In this regard, although the purification of ricin is relatively simple for persons with biochemical expertise to carry out, and is available in the published scientific literature, the quality of the material produced by amateur workers has generally been crude, yielding oily substances with larger particle sizes and poor aerosolization characteristics. While this has been a common finding, it should be borne in mind that aerosolizable ricin has been produced in the past and that this material may have a more uniform particle size distribution and improved aerosolization properties, thereby increasing the risk to responders and the potential for spread of the material by re-aerosolization when contaminated items are moved or disturbed by air currents.

The extent of the contamination includes the amount of ricin and a consideration of the pathways by which it might have been spread. It is determined by adapting environmental and industrial hygiene survey and sampling methods. The decontamination strategy, in the general case, has to deal with a variety of locations, structures, conditions, materials, and other factors. Beginning with the first indications or reports of an event involving contamination of some type, a survey and sampling process is initiated to provide definition and detail concerning the nature of the contamination, its precise locations, and its extent. For example, if the release is limited to powder from a letter or container, then a sampling plan starting at an area generally free of contamination and working in concentric circles towards the release point is deemed very effective. Other areas that may have become contaminated due to foot traffic (e.g., mail trail, elevator buttons, light switches) should also be considered suspect vectors. If the release involved an aerosolizable material, than the possible airborne distribution needs to be considered. The survey and sampling process continues throughout decontamination operations as a means of confirming the effectiveness of the methods chosen.

The results of sampling for contamination should make it possible to distinguish between contaminated and uncontaminated areas and to determine the types of surfaces involved. To prevent the spread of contamination by movement of workers or equipment, it is advisable to isolate the contaminated area. The decision to establish an isolation area should be made in consultation with public health experts. If the area of contamination is small, discrete, and confined to limited surfaces, it may suffice to simply cordon off the area. Larger areas can be closed off using polypropylene sheeting, tape, and other products. If needed, a higher level of isolation can be achieved by creating negative air pressure to prevent the outward flow of air. A negative pressure environment can be produced by using portable HEPA-filtered negative air units in the affected areas.

Decontamination and cleanup include the following set of activities, which are the focus of this chapter:[2]

- Establish environmental clearance committee and set clearance goals
- Develop Remediation Action Plan (RAP)
- Site preparation and source reduction
- Decontamination
- Waste disposal
- Clearance sampling and analysis
- Clearance decision.

8.1.1 Planning and preparing for decontamination

Cleaning an area or item contaminated with ricin involves numerous and variable issues that are specific to individual locations. No single technology, process, or strategy will be effective in every case. Responders must develop a decontamination strategy that takes into account both the nature and extent of decontamination as well as the specifics of the contaminated environment.

8.1.1.1 Clearance committee and clearance goals

Clearance goals are set based on the results of the risk assessment as well as careful consideration of scientific uncertainties.[2] All stakeholders – local authorities, building owners and residents, Federal, State, and local environmental and health agencies, the affected public, and others – should be consulted before decontamination begins and informed of the clearance goals. Representatives from these organizations may be appointed to serve on the Environmental Clearance Committee (ECC), which reviews and evaluates relevant cleanup data and makes recommendations as to whether the remediation should be judged successful (see section 8.2.3).

8.1.1.2 Remediation action plan

This decontamination strategy is detailed in the RAP, which describes the characterization of ricin, containment measures, worker protection and decontamination, clearance goals, site preparation, source reduction, waste disposal, decontamination of affected sites, off-site decontamination of essential items, decontamination verification, clearance environmental sampling and analysis plan summary, and clearance decision-making criteria.[3]

A site safety plan is needed to protect workers inside and outside the contaminated area, as well as the surrounding population. See chapter 3 for more information on worker health and safety. The facility manager should notify employees and others of the nature and scope of the work and its expected duration.

8.1.1.3 Site preparation and source reduction

Site preparation for a fumigation approach (which may not be appropriate for all situations) includes the following tasks:[2]

- Assembling a worker decontamination unit
- Testing a facility for leaks
- Constructing internal waste processing and load-out units
- Installing and testing chemical generation systems
- Installing and testing chemical, temperature, and humidity monitoring systems
- Installing and testing negative air and air scrubbing systems
- Subdividing existing space with temporary walls.

Clearing and sorting items in the contaminated area may be necessary in order to enhance the efficiency and safety of decontamination operations. Consideration should be paid to items that hamper access, block surfaces, require special handling, in some way impede the overall progress of operations, are best processed in like groups, or, constitute a trip or other safety hazard to personnel. Items such as computers, including keyboards, telephones, books, pictures, furnishings, loose papers, and personal items may be collected, sorted, labeled, and recorded into an overall tracking and documentation system. Such items may be decontaminated in centralized areas on site or transported to remote facilities most appropriate for that purpose.

Important decisions may be made on the spot, or as a result of prior planning, to discard selected items that are either not suitable or not of sufficient value to warrant decontamination with the intention of reuse. Such decisions increase the options for decontamination of these items that should still be necessary prior to their disposal, since damage will no longer be an issue. Similarly, scanning papers, copying computer files, and other similar operations may be employed to salvage information, restore normal operations, and, again, to reduce the need for decontamination.

8.1.2 Decontamination and waste disposal

Initial contamination reduction and gross area decontamination may then proceed. Reducing debris facilitates subsequent HEPA vacuum operations to reduce surface contaminant levels and the potential for re-aerosolization. Gross decontamination decreases the potential for spread of contaminations as well as minimizing the contamination to which decontamination workers are exposed. Floors, walls, ceilings, counters, or desk surfaces may then be wiped clean or treated as required. If necessary, floor tiles, rugs, wallpaper, partitions, etc., can then be further treated in place or removed as appropriate. This iterative process may be done room-to-room or floor-to-floor, or it may involve wholesale removal and transportation of items to separate locations. Equipment associated with building utilities, such as water, power, and ventilation, including ducting, may then be accessed and, if necessary, also treated.

Documentation and tracking of all operations are important parts of the organizational plan and it is necessary to ensure that decontamination tasks are ordered, accomplished, and confirmed. Such a system should be designed and put in place as soon as possible, including chain-of-custody protocols for collection and transportation of sensitive materials. Sample custody must be documented throughout collection, shipping, and analysis of the samples as follows: the chain of custody forms should summarize the samples collected and analyses requested. Each entity/organization handling the specimens is responsible for the specimens only during the time that each has control of the specimens. Each entity/organization receiving the specimens must sign off on the chain of custody form of the entity/organization relinquishing the specimens to close that chain. When receiving specimens, each new entity/organization must begin its own chain of custody and have the entity/organization relinquishing the specimens sign its chain of custody to start the chain and indicate that it has transferred the specimens. When specimens are transferred between entities/organizations, each entity/organization retains its chain of custody forms. The recipient must verify that all samples identified on the custody forms are present in the shipping container. Any discrepancies should be noted on the form and appropriate authorities contacted.[a]

The HVAC ducts serving the affected area may also need to be sealed. Plastic sheeting, tape, or other products can be used to minimize the movement of air and contamination in or out of these ducts. The ducts can be sealed within the affected room or at external locations as long as the selected decontamination technology effectively decontaminates the ductwork between the room and the external seal. An HVAC specialist should be consulted.

Decontamination should address the following:

- <u>Hidden sources of contamination</u>—Desktop computers and other objects with internal fans that draw air into the case may have filters or electrostatic devices to control the dust intake. These filters or the equipment chassis may be a reservoir of contamination. If the selected technologies may damage the item or may not penetrate to hidden locations, then these items may be dealt with in an alternative manner. The manufacturer of the device should be consulted if it is to be saved for reuse.
- <u>Pre-cleaning</u>—Excessive amounts of dirt of other organic material on the surface to be decontaminated may decrease the effectiveness of the selected decontamination method. Using certain techniques, such as HEPA vacuuming, to remove some of the dirt and debris could reduce the need to perform more aggressive chemical decontamination.
- <u>Removal of items</u> – To reduce potential spread of contamination, items should be decontaminated in place. If the selected technology will destroy an item that must be salvaged, then the item may be removed and decontaminated elsewhere with an alternative technology. This requires a means of safe transport and a separate isolation chamber, which adds complexity to the decontamination process.

Other considerations and lessons-learned from the Dirksen ricin incident include the following:

- Facts available at the time of the incident concerning the effectiveness of specific methods for decontaminating ricin were found to be unreliable.
- Perceptions of risk drove the process towards the need to achieve a level of decontamination that left no measurable cytotoxicity assay activity. (This statement does not say that the samples did not have any activity after the assay.)
- No health-based risk assessment was used to determine what might constitute an acceptable level of residual activity.
- Practicality was a strong driver in the choice of decontamination methods.
- The methods employed, while effective for the decontamination of a relatively confined area, would be very expensive and time consuming if used to decontaminate a larger area.

[a] Sample chain of custody procedures should be in accordance with ASAT II-007, *Standard Operating Procedure for Chain of Custody for Dioxin/Furan Analysis*.

- Documentation and tracking of items removed from the office building was important because some items needed to be located after removal.

See sections 8.3 and 8.4 for more detailed information on decontamination technologies and waste disposal methods. Some of these methods have not been validated against ricin specifically; they are presented believing that they may be effective based on their efficacy against other agents (e.g., anthrax).

8.1.3 Environmental sampling

There are three types of environmental sampling:[2]

- Screening environmental sampling is the initial collection of a limited number of environmental samples to determine whether contamination is present and, if so, determine approximate locations of contamination from ricin and semi-quantitative estimates of the concentrations of the agent at those locations, where possible. This is completed as part of the site characterization and risk assessment process.
- Characterization environmental sampling is conducted to confirm or disconfirm preliminary hypotheses developed from screening results and develop more advanced hypotheses for better characterization.
- Clearance sampling and analysis is performed as the ultimate test of whether a remediation process has been successful.

The most common sampling method is Wipe Sampling, where synthetic (Dacron or rayon) wipes pre-moistened with phosphate buffer solution or deionized water is used. Samples may also be collected using Microvacuum Sampling, recommended for the collection of characterization samples of the ricin for forensic and toxicological testing. As stated above, maintaining appropriate chain of custody documentation and procedures for sample collection and following guidelines and regulations for submitting samples to the laboratory for analysis should not be overlooked in the sample collection and analysis process. See chapter 4 for more information on sampling.

The characterization environmental sampling and analysis plan (SAP) articulates the overall strategy specific to the contaminated site, lists the methods and tools to be employed (primarily environmental sampling), and describes how those tools are applied to implement the strategy.[2]

When all decontamination procedures have been conducted and verified, additional Clearance Environmental Sampling is performed to determine whether the remediation process has been successful and persons may be allowed to return to the area without PPE. Clearance Sampling is the primary means of demonstrating the absence of the biological agent and the success of the remediation, with the criterion for success being "no growth" or "no positive" on any clearance environmental sample collected. The criterion for success is developed specifically for each site and the specific biological agent involved, taking into account the potential risks of the agent and amount and type of sampling needed to provide a high level of confidence in a decision (clearance decision) to declare the remediation successful.

Acute Exposure Guideline Levels (AEGLs) and Emergency Response Planning Guidelines (ERPGs) can be used to conduct appropriate hazard analyses and consequence assessments for chemical events.

EPA's National Homeland Security Research Center (NHSRC) has developed the Technology Testing and Evaluation Program (TTEP) as an extension of EPA's Environmental Technology Verification Program (ETV). The program evaluates the performance of innovative environmental technologies used in the detection of chemical and biological agents. Verified and approved technologies for detection of ricin include antigen-capture ELISA and BioThreat Alert Immunoassay Test Strips by Tetracore, Inc., BADD Immunoassay Test Strips by ADVNT Biotechnologies, and RAMP Immunoassay Test Cartridges by Response Biomedical Corp. A more universal technology used to detect toxins in air, water, soil, and sediment is the Deltatox Rapid Toxicity Testing System; however, testing and verification of this product have shown it not to be highly responsive to varying concentration levels of ricin agents.[b]

8.1.4 Clearance decision process

It is important that clear objectives or clearance goals for decontamination are set and agreed upon by all stakeholders. This is a difficult process when there are no published standards, as in the case of ricin.[c] The clearance decision is ultimately determined by the Incident Commander/Unified Command (IC/UC) or an independent advisory panel of multidisciplinary experts called an Environmental Clearance Committee (ECC) appointed by the IC/UC, if desired. Such a judgment is based on a thorough analysis of all sampling, process, and other data that are pertinent to the criteria for success as outlined in the SAP and RAP. The ECC is usually formed early in consequence management so it can be informed of, and have input into, the environmental sampling concepts to be used in developing the SAP. The ECC, an independent advisory group, does not participate in the decision-making process for the decontamination. When decontamination activities and clearance environmental sampling are completed, the ECC reviews all pertinent data and provides a recommendation to the IC/UC as to whether the remediation has been successful and the biological agent is no longer present at a level that poses a significant risk to human health.[2]

[b] More information on ETV verification test results on these technologies, including cost information, can be obtained at http://www.epa.gov.

[c] The EPA has been tasked with determining their own standards for reoccupancy of a building after a ricin event, as no specific EPA standards exist for ricin at present.

8.2 Decontamination Methods and Technologies

This section provides an overview of different types of methods and technologies available for decontamination of ricin. Specific EPA recommendations are summarized in the opening table. The TTEP program, discussed earlier, currently has no published reports on the efficacy of decontamination technologies on ricin.

The use of proper PPE is recommended for all workers exposed to dilute sodium hypochlorite and/or sodium hydroxide solutions used for decontamination. In addition, cleanup workers are advised to wear respiratory protection (full face respirator with combination acid gas/particulate filter for chlorine bleach, or particulate filter for sodium hydroxide and gloves (butyl rubber, neoprene, nitrile, or polyethylene) as safeguards against chemical burns to the skin and airways.[3] See chapter 3 for more information on worker health and safety.

8.2.1 Chemical decontamination

Chemical treatment includes a wide variety of decontamination reagents that may be applied to agents. The chemical can be applied either in dry or liquid form, or as gases, appropriate to the agent(s) being decontaminated. Gases are usually applied in a specially constructed chamber, or for a larger structure, as a fumigant in a tented or otherwise sealed enclosure. Chemical treatments available for possible use with ricin are discussed below.

8.2.1.1 Sodium hypochlorite

A 0.5% sodium hypochlorite solution prepared from household bleach, with its pH lowered into the 6-8 range by adding distilled white vinegar, is generally used.[3] Household bleach is typically a 5%-6% solution of sodium hypochlorite in water. When household bleach is diluted according to the directions with commercially available distilled white vinegar and tap water, it forms a 0.5%-0.6% sodium hypochlorite solution (1:1:10 volute/volume/final volume) at approximately pH = 7. For sensitive materials, use a 0.125% (1:4 dilution of commercially available solution) solution.

For items from outside the prime area with hard, non-porous surfaces of concern, wipe with a sponge wetted with 0.1% sodium hypochlorite solution (1:5 dilution of the standard 0.5% decontamination solution). The first wiping should be done in one direction, then the item should be wiped in a direction oriented 90 degrees from the original direction. The second wipe should not be conducted without rinsing the sponge. The item should then be wiped dry and returned to the owner. Items from the area of primary concern should be wiped, sampled, and analyzed for the presence of ricin. If the sample results are negative for the presence of ricin, the item would be returned to the owner. If the sample results are positive for the presence of ricin, the item is decontaminated with a 0.125%-0.5% sodium hypochlorite solution or thermal inactivation and then resampled for the presence of ricin. The decontamination and sampling process is repeated until the item tests negative for the presence of ricin.[3]

8.2.1.2 Ethylene oxide

Ethylene oxide (EtO) is a gas long used by hospitals for sterilization of instruments and other small items. It is extremely reactive and is highly dangerous to unprotected workers, both acutely as well as because of its potential carcinogenic properties. EtO treatments for a duration of 24 hours at 815 mg/l, relative humidity of 35%, were shown to be highly effective in reducing ricin activity. Some modest residual activity (much less than 1%) remained following a single cycle of EtO treatment. EtO use is likely to be confined to decontamination of selected items in relatively small chambers.

8.2.1.3 Chlorine dioxide

Chlorine dioxide (ClO_2) gas is an oxidizing agent and has been found to be highly effective in decontaminating anthrax. It may be useful in decontaminating ricin, although it has not yet been validated for that purpose. Chlorine dioxide has been found to be relatively sparing of damage to most materials, although there are exceptions. It presents an extreme hazard to workers, and unprotected exposure must be avoided. Employing chlorine dioxide to decontaminate a building is a significant undertaking, which requires specialized tenting or other effective containment measures, as well as specialized gas generating equipment, entailing a substantial amount of planning, expense, and time.

8.2.1.4 Vaporous hydrogen peroxide

Vaporous hydrogen peroxide (vHP) is a method similar to the use of the above reactive gases but distinct in that the vHP requires somewhat higher moisture content and, thus, is not a dry application. The capacity of vHP to penetrate materials is probably less than for ClO_2 or EtO. Questions still remain about any secondary potential health risks to responders.

8.2.2.5 Paraformaldehyde

Paraformaldehyde (pHCHO) produces formaldehyde gas when heated. Formaldehyde is reactive with proteins and, therefore, potentially reactive with the proteinaceous ricin molecule. It is not validated for decontamination of ricin. Formaldehyde is reasonably anticipated to be a human carcinogen[d], and the toxicity of residuals is problematic.

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[d] 11th Report on Carcinogens, National Toxicology Program <http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s089form.pdf>

8.2.2 High efficiency particulate vacuuming

High Efficiency Particulate Vacuuming provides a means of reducing gross levels of contaminants on surfaces. This approach is clean, does not damage materials, does not generate waste by-products other than those present in the filters themselves, and can achieve substantial reductions in the gross contamination load on surfaces. It also reduces the potential for re-aerosolization of ricin. It is limited by the number of vacuum units available, the volume of air or areas of surface that need to be cleaned, and the availability and expense of HEPA filters. It is primarily an approach for use indoors.

8.2.3 Thermal inactivation

For a high-confidence procedure, ricin should be treated for 24 hours at 80% relative humidity and 200 °F (93 ºC). It is possible that results could be achieved with higher temperatures for shorter periods of time. This combination of moisture and heat appears to be more effective than dry heat alone. It is important to evenly space all containers undergoing treatment for an even distribution of heat. Other chemical fumigations such as EtO may prove more useful.[3]

Combined Heat and Ethylene Oxide treatment was shown to be highly effective in eliminating ricin activity levels below the threshold of detection. The treatment consisted of exposing ricin-contaminated materials to an EtO concentration of 815 mg/l and a temperature of 176 ºF (80 ºC), relative humidity of 35%, for a duration of 24 hours. Steam heating is unlikely to be a reliable method for ricin, due to the relative difficulty of controlling the temperature and exposure duration. Irradiation is impractical for decontamination of ricin. An exposure of approximately 75 MRad was observed to reduce the enzymatic activity of the A-chain of ricin by 90%, and even an exposure of 100 MRad was not 100% effective.

8.3 Waste Disposal

Ricin is not a Resource Conservation and Recovery Act (RCRA) hazardous waste (because it is neither listed nor characteristic). The Department of Transportation (DOT) lists ricin as UN# 3172 (Guide 153) and as Hazardous class: 6.1(a); consequently, the waste is not hazardous per DOT.[1] This section emphasizes the importance of consulting with State and local waste management authorities, identifies the possible types of contaminated wastes, including wastewater, explains the need to notify waste and recycling service providers of potential contamination, and describes how to manage wastes that are or may be contaminated.

It is important to contact the State or local regulatory agency early on to determine what state or local requirements apply and what treatment and disposal options are available. State authorities have primary responsibility to regulate and oversee management of wastes that may be contaminated with an infectious agent (which is not the case with ricin). In addition, DOT and other pertinent agencies should be consulted if there are any questions about transporting wastes that are contaminated with infectious agents. According to the EPA, wastes from most building contamination sites are usually shipped via truck, rail, or barge, with the most appropriate transportation mode depending on the proximity of the waste site and eventual waste management location to railroads and barge stations, existing infrastructure, equipment availability on short notice, public acceptance, and overall project cost. On-site coordinators need to be familiar with DOT regulations and those of State transportation authorities.[4]

The most common types of wastes resulting from assessment and decontamination of anthrax contamination include the following:

- PPE and other materials used in assessment and decontamination
- Debris intended for disposal
- Wastewaters generated during decontamination.

Debris intended for disposal could include the following:

- Small materials removed from the building (e.g., books, papers, pictures and wall hangings)
- Small equipment and office items (e.g., staplers, telephones, hand tools)
- Large durable materials removed from the building (e.g., furniture, computers, copiers, fax machines, printers)
- Building and decorating materials such as carpeting, draperies, window blinds, window air conditioners, ceiling panels, wallboard, and paneling
- Mail suspected of contamination, identified and processed in accordance with U.S. Postal Service regulations
- Trash, food, and other unwanted materials present at the site at the time of contamination.

Debris consists of material removed prior, during, and after the decontamination process that is sent to a permitted disposal facility. The majority of the debris consists of porous materials, due to the inability of post-cleanup sampling to assure complete agent destruction in such materials. The primary means of disposal for ricin-containing waste is through high-temperature thermal incineration or through landfilling in a lined landfill operating under RCRA Subtitle D. It is important to contact potential waste disposal facilities early on in the response, so that appropriate arrangements can be made and potential regulatory and technical obstacles can be identified.[4]

Wastewater generated during decontamination can include chemicals used to treat PPE, subsequent rinses, and air scrubber waters associated with fumigation. No decontamination wastewater should be discharged until the water is treated in accordance with appropriate guidelines and until agreements have been reached with, and approved by, the local utility manager, publicly owned treatment works operator, and public health officials. These agreements should specify, at a minimum, the exact volume and rate of flow at which the decontamination wastewater will be discharged to the collection system or treatment plant and the exact time and location of the discharge.

Once the decontamination wastewater is properly contained/stored and the decision is made to discharge the wastewater to the sewer, the individual in charge of cleanup operations or IC should contact the wastewater authority that will ultimately receive the wastewater at its treatment plant. EPA strongly recommends that communication with wastewater authorities be established prior to initiating disinfection of the decontamination wastewater. The IC should work with the wastewater authority to ensure that the protocol for disinfection meets the authority's needs. Once disinfection is complete, the IC should notify the wastewater agency and formally request (in writing) approval for discharge of the decontamination wastewater. The ultimate decision to allow the discharge of the decontamination wastewater into the sewer lies with the wastewater authority.[5]

Workers conducting sampling or disinfection of decontamination wastewater or otherwise involved in activities that place them at risk for exposure to ricin should wear PPE, including respiratory devices, protective clothing, and gloves. Workers should also take the appropriate precautions when handling disinfection agents.

References

[1]Environmental Protection Agency, *Ricin Quick Reference Guide for EPA First Responders*, June 1, 2004.
[2]Cleanup Decision-Making Guidance for Biological Incidents, Biological Decontamination Standards Working Group, Draft version 9, September 26, 2005.
[3]EPA Fact Sheet, Appendix A, June 2, 2004, <http://www.epaosc.org/CapitolHillRicin>
[4]DOT, "Guidelines for transporting anthrax and anthrax-contaminated objects and materials," <http://www.hazmat.dot.gov/guide_anthrax.htm>
[5]The protocols for safe handling, treatment, and disposal of wastewater during decontamination were determined by subject matter experts (SMEs) from the Centers for Disease Control and Prevention (CDC), States, and the Association of Metropolitan Sewerage Agencies (AMSA) to be applicable for *Bacillus anthracis* spore contamination.

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Glossary

AEGL - Acute Exposure Guideline Levels
APR – Air Purifying Respirator
CBRN – Chemical, biological, radiological, nuclear
CDC – Centers for Disease Control and Prevention
ClO_2 – Chlorine dioxide
DHS - Department of Homeland Security
DOJ – Department of Justice
DOT - Department of Transportation
DTAC - Disaster Technical Assistance Center
ECC - Environmental Clearance Committee
ECOT - Emergency Communications and Outreach Team (EPA)
ED – Emergency department
EMS – Emergency Medical Services
EOC – Emergency Operations Center
ELISA - Enzyme-Linked Immunosorbant Assay
EM – Electron microscopy
EPA - Environmental Protection Agency
ERPG - Emergency Response Planning Guidelines
ESF - Emergency Support Function
EtO – ethylene oxide
ETV - Environmental Technology Verification Program (EPA)
FBI - Federal Bureau of Investigation
GAO – General Accounting Office
GC/MS - Gas chromatography/mass spectroscopy
HAN – Health Alert Network
HASP – Health and Safety Plan
HAZMAT – Hazardous materials
HAZWOPER - Hazardous Waste Operations and Emergency Response Standard
HD – Health department
HEPA - High Efficiency Particulate Air
HHA – Hand Held Assay
HHS – Department of Health and Human Services
HSOC – Homeland Security Operations Center
HSPD-5 – Homeland Security Presidental Directive 5
HVAC - Heating, ventilation, and air conditioning
IC – Incident Commander
IgG – Immunoglobulin G
IgM – Immunoglobulin M
JFO – Joint Field Office
JIC - Joint Information Center
JOC – Joint Operations Center
LC/MS – Liquid chromatography/mass spectroscopy
LD_{50} – Lethal Dose, 50%
LRN – Laboratory Response Network

MALDI-TOF MS Matrix-assisted laser desorption/ionization time-of-flight mass spectroscopy
NCP – National Contingency Plan
NHSRC - National Homeland Security Research Center (EPA)
NICCL - National Incident Communications Conference Line
NMRC - Naval Medical Research Center
NRC – National Response Center
NRP - National Response Plan
NRT – National Response Team
OPHEP - Office of Public Health Emergency Preparedness
OSC – On-scene coordinators
OSHA – (Department of Labor) Occupational Safety and Health Organization
PAPR - Powered Air Purifying respirator
PCR – Polymerase Chain Reaction
PIAT - Public Information Assist Team (US Coast Guard)
PPE – Personal Protective Equipment
PTSD – Post-traumatic stress disorder
RAP –Remedial action plan
RRCC – Regional Response Coordination Center
RCRA - Resource Conservation and Recovery Act
SAP - Sampling and analysis plan
SCBA – Self contained breathing apparatus
SEB - Staphylococcal enterotoxin B
SME - Subject Matter Experience
TEEL - Temporary Emergency Exposure Limits
TRF - Time-resolved fluorescence
TTEP - Technology Testing and Evaluation Program (EPA)
UC – Unified Command
USAMRIID – US Army Medical Research Institute of Infectious Diseases
USCG – United States Coast Guard
USDA – United States Department of Agriculture
USPS – United States Postal Service
vHP – vaporous hydrogen peroxide